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AN ANALYSIS OF THE NAVY REGIONAL DATA AUTOMATION CENTER (NARDAC) CHARGEBACK SYSTEM

by

William Arthur Potter

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An Analysis of the Navy Regional Data Automation Center (NARDAC) Chargeback System

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ABSTRACT

A data processing chargeback system is one of the most important tools for management control of computer resources. Users are coordinated and controlled through the impact of life cycle budgets and transfer prices on demand for computer products and services. Computer resource decisions concerning configuration and magnitude are also impacted by life cycle prices. This concept is used to explain some current chargeback accounting systems and to provide the foundation for development of preferred chargeback objectives and measurement criteria (or standards). Evaluation of data processing management performance requires setting user understandable criteria. To that end, emphasis must be shifted from a purely inward looking perspective to a "user oriented perspective." Using the inial concept as a foundation, the author leads the reader through a step-by-step process that introduces, develops, and expands the above points and culminates in a suitable environment for this user oriented perspective.

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I. INTRODUCTION

A. OBJECTIVE AND PURPOSE

The objective of this thesis is to separate, from the perspective of a chargeback management control system design, what academic and organizational areas are of most relevance and which particular aspects of each an organization should include in its synthesis of a chargeback system concept. This method of approach should provide the reader with a clearer insight into the theory of chargeback, its implicit biases, its academic home, and its selective focus.

The thesis is designed to stress the important point that to gain a robust perspective of what a chargeback system is; it is essential to examine both the academic and actual operational aspects. After a careful analysis of the two areas, the author adds his own integrative perspective. This integrative perspective highlights and brings to the fore some areas that the current academic and operational views either completely ignore or deemphasize. In particular, the author's contribution serves to shift the emphasis from the technological (or inward looking) perspective to the managerial (or outward looking) perspective.

The thread used to tie the various chapters together is the argument advanced by Bernard et. al. (1977) that chargeback should be regarded not simply as a cost recovery mechanism but as a tool for management control. To be effective, a chargeback system must not only be aligned with the particular circumstances within which it will operate, but must also coordinate and control the cost of computer operations, computer capacity, and user demand.

This thesis does not attempt to specify an "ideal" form of a chargeback system. Instead, it lays out principles, considerations, and alternatives so as to provide guidance in dealing with a chargeback system in a management control environment.

In an attempt to understand chargeback, it is first necessary to examine the basic fundamentals of the business of managing data processing (DP) services in general. An approach of this nature requires a wide perspective. This chapter develops that perspective by providing the reader with:

(1) a general overview of a Navy Regional Data Automation Center's (NARDAC) Mission;

(2) a clear understanding of the type of management control system being examined and discussed;

(3) the role that a management control system plays in an organization;

(4) a brief introduction to the reasons for implementing a chargeback control system;

(5) a look at some of the design issues for a chargeback control system;

(6) an overview of how the thesis is organized.

B. NAVY REGIONAL DATA AUTOMATION CENTERS MISSION

Navy Regional Data Automation Centers (NARDACs) are the Navy's general purpose data processing (DP) centers operating under the auspices of the Naval Data Automation Command (NAVDAC). In the private sector, a Navy Regional Data Automation Center (NARDAC) could be compared to a large information processing service agency. A NARDAC's raison d' etre is to provide high quality, low cost, general purpose DP services to support activities (clients) in regions of high concentration of Navy commands. Each NARDAC is operated as a non-profit service facility dedicated to improving the quality and efficiency of computing services available to Navy activities within its geographical boundary. Typically, the DP services offered by a NARDAC range from one time technical consultations to the full range of tasks involved in software and hardware project development, and processing applications on a scheduled production basis. Therefore, most of the management literature that deals with corporate general purpose DP management can be applied to the study of NARDACs.

C. CATEGORIZING CONTROL SYSTEMS

A well known and respected taxonomy of organizational control systems was developed by Anthony (1965). Anthony views managerial activities as falling into three categories and argues that each is sufficiently different in kind to require distinctive planning and control systems. The first of these categories is strategic planning. Strategic planning according to Anthony is:

> The purpose of deciding on objectives of the organization, on changes in the objectives, on the resources used to attain these objectives, and on politics that are to govern acquisition use, and disposition of resources. (1965, p. 24)

Defining objectives implies an emphasis on scanning the organization's environment. The strategic planning process typically involves senior management and analysts and requires lots of innovation and creativity.

The second category is management control. Anthony defines management control to be:

> The process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives. (1965, p. 27)

Anthony stresses three key issues in management control:

(1) the activities of management control involve considerable inter-personal interaction;

(2) it takes place within the context of the policies and objectives developed in the strategic planning process;

(3) its paramount aim is to assure effective and efficient performance.

Anthony's third category is operational control. Operational control is the process of assuring that specific tasks are effectively and efficiently carried out. In addition, operational control is concerned with performing predefined activities whereas management control relates to the organization's goals and policies. There are less "judgement calls" required in operational control, because the tasks, goals, and resources have already been explicitly defined (Anthony, 1965).

Anthony, as well as many other noted authors, among them Keen and Scott Morten (1978), and Sprague and Carlson (1982), recognize that the three control boundaries are not clear-cut and often overlap. Anthony's definitions are, however, useful for analyzing information system needs and activities.

The information needs of each of the three categories are very different. For example, the strategic planning area is primarily concerned with collecting data about the organization's environment (i.e., economic, political, community image, etc.) (Fink et. al., 1983). Operational control is concerned with data on how efficient and effective specific day-to-day tasks are being performed (Fink et. al., 1983). Management control, on the other hand, requires data on the efficiency and effectiveness of the organization's overall performance.

Administratively, users of a data processing center are coordinated and controlled as elements of the management control system through their demand for computer products and services (Ein-Dor and Jones, 1985). In the chargeback environment, the controlling mechanism is the chargeback system and user DP budgets. The budgets are for the life cycle of the system, each placing an upper bound on the life cycle expenditures for a specific user (Ein-Dor and Jones, 1985). Therefore, chargeback seeks to balance the DP system and to provide the users with information they perceive to be of maximum value over the system's life cycle.

Clearly, the managerial control framework provides the proper perspective for analyzing the effects of a chargeback system. Accordingly, the emphasis throughout this thesis will be from the managerial control perspective.

D. ROLE OF MANAGEMENT CONTROL SYSTEMS

A management control system may be viewed as a network of "sensors" that sense the organization's operations. It focuses primarily on guiding the organization on a year-to-year basis. The control system, however, does the guiding in such a manner as to be consistent with the organization's long-range planning strategy (Cash et. al., 1983). In effect, the management control system monitors the progress of operations and alerts the "appropriate management level" when performance as measured by the system deviates from established standards. To be effective, the management control system must be capable of: incorporating the sophistication of the users; the geographic dispersion of the users; the stability of management; and the interdepartmental relationships with the service organization (Cash et. al., 1983).

The typical management control models found in the chargeback literature tend to stress the financial control architecture, the financial control processes, and the audit function (Brandon, 1978; Anderson, 1983). In an operating DP environment, however, non-financial management control is just as important for ensuring efficient and effective utilization of computer products and services. For example, DP management must constantly survey the computer services market and its user community to determine the adequacy of DP support being provided. The results of the survey should be used to ascertain where improvements in computer efficienty and/or service effectiveness can be made. In addition, DP management must plan and forecast user requirements for the purpose of long-range system, software, labor acquisition, and utilization planning.

E. CONCEPTS UNDERLYING A CHARGEBACK CONTROL SYSTEM IMPLEMENTATION

One of the most popular management techniques for attempting to control DP is the implementation of a chargeback system (Dearden and Nolan, 1973; Bernard et. al., 1977). In a chargeback system, users are charged an appropriate fee, computed by formula, for their use of computer products and services on a job-by-job basis.

Ein-Dor and Jones (1985) advance the argument that charging for computer resource usage creates an environment wherein the computing resource functions as a "utility" that serves the user organization. They emphasize the fact that maintaining an accurate and equitable pricing system over time is a complex task requiring detailed planning, careful monitoring of change and periodic adjustments. Moreover, they argue that the pricing mechanism employed must at least measure computer workload in terms of supply and demand for computer products and services in an economic sense across the major components of the corporate organizational structure for the life cycle of the system.

McFarlan (1973) states that reporting from a chargeback system is "crucial" for monitoring overall performance and identifying sources of problems. Nolan (1977) enhances McFarland's argument by pointing out that an effective chargeback system is "essential" if users of computing resources are to be in control and held accountable for the services they receive. Although implied but never explicitly stated is the assumption that to be effective, a chargeback management control and reporting system should be employed to point out control problems, not necessarily to find wrong doers.

F. PROBLEMS FACING CHARGEBACK CONTROL DESIGN

The fairly recent and rapid growth of information systems technology has created new challenges for DP management. Major investments in computing hardware and application software coupled with the ever expanding role of DP has had a profound effect on the management of these organizations. Organizations have goals that change over time and, therefore, require a control system mechanism that must be sufficiently flexible to continue to meet those changing goals (Anthony and Dearden, 1980; Euske, 1984). A poorly developed, implemented, and managed or inflexible chargeback control system can have grave consequences on the management of a computing facility. The effects can range anywhere from capacity saturation and low prices to low demand and high prices (Dearden and Nolan, 1973). Therefore, the argument is introduced that for a chargeback control system to be effective, it must:

(1) provide financial control for the purpose of ensuring efficient and effective use of computer products and services;

(2) provide a means to effect DP-user goal synchronization. That is, instead of communicating hardware resource utilization, the chargeback system should enable the users, DP, and executive management to communicate service requirements, policy, and corporate directives.

G. THESIS ORGANIZATION

Chapter I began by introducing the reader to the objectives and purpose of the thesis. Additionally, the following points were developed and discussed in order to provide the reader with the proper background for understanding chargeback: (1) NARDAC's Mission; (2) a definition of a management control system; (3) the role that a management control system plays in an organization; (4) a brief overview of a "generic" chargeback system; and (5) some issues facing design of a chargeback management control system.

Chapter II provides a more in-depth look at a typical NARDAC by examining: (1) its mission and function; (2) its organizational structure; and (3) its client-users.

Chapter III provides a basic academic overview of a chargeback system. The following topics are discussed in-depth: (1) the establishment of management goals; (2) the objectives of a chargeback system; (3) the typical accounting systems used in a chargeback system; and (4) typical chargeback performance standards (or criteria).

Chapter IV discusses the NARDAC chargeback system in-depth. In particular, the NARDAC's management policy and objectives for the system, billing algorithm and rate determination, performance criteria, and performance evaluation methods are discussed.

Chapter V prescribes what the author considers to be the preferred chargeback objectives that all chargeback systems, including NARDACs, should espouse. Within the chapter, it is argued that the most important objectives are: (1) financial control; and (2) DP-user goal synchronization. How the DP organization through the use of chargeback attempts to attain these objectives can have a direct effect on how the organization is viewed by the user community. Additionally, the chapter introduces some management guidelines that provide a simplistic, but nevertheless, viable framework for bridging the gap between planning and a chargeback system. The framework, if properly applied and managed, should move a DP organization along the road to attaining the preferred objectives and, furthermore, put to rest the argument that "effective planning" for future systems cannot be done properly in a chargeback environment.

Chapter VI presents what the author considers to be preferred chargeback performance criteria. Within the chapter, it is argued that chargeback performance criteria must be understandable and to some extent, controllable by the user if the objectives of Chapter V are to be attained. A strategy for accomplishing this feat is presented. The necessary DP-user bridge is a DP Service Agreement.

Chapter VII explores both the concept and application of measurement as it relates to the management of DP. Measurement is an abstract concept that is glossed over, if its addressed at all, in most management literature on chargeback (Anderson, 1983; Cortada, 1980; Schaeffer, 1981). Therefore, good literature in this area is extremely sparse. Within the chapter, the author advances the argument that:

(1) measure in a DP enviornment is not as objective as many people believe;

(2) does not exist away from the application it purports to measure; and

(3) cannot be transported from application to application or from organization to organization.

To this end, emphasis is placed on answering such diverse questions as:

(1) What is measurement?;

(2) What are the functional dimensions of measurement?;

(3) What is the theory behind the development and application of measurement standards?; and

(4) What measurement tools are needed in a preferred chargeback environment such as that presented in Chapters V and VI?

Chapter VIII prescribes an "ideal climate" for the effective operation of the NARDAC chargeback system. While the discussion may be slanted toward the Navy's DP environment, the arguments apply equally well to a DP organization within a commercial enterprise. First, a two-tiered structure for a NARDAC is recommended. The lower level consists of a well-structured, well-controlled procedures that include the chargeback system. The second level has sufficient slack in terms of dollars and personnel so that a NARDAC can maintain a research and development focus. Secondly, a joint user-DP educational design effort starting at the NAVDAC level is called out.

Chapter IX is a recapitulation of the important points developed and discussed within the thesis.

II. BACKGROUND OF THE NAVY REGIONAL DATA AUTOMATION CENTERS

A. INTRODUCTION

Before an analysis of the Navy Regional Data Automation Center (NARDAC) chargeback system can be made, it is necessary to have a basic understanding of the NARDAC organization and environment. This chapter provides the reader with that basic understanding by taking a broad look at the mission and functions of the Navy Regional Data Automation Centers (NARDACs) and then moving in for a close examination of the typical organizational structure and users of a NARDAC. For a more comprehensive study of the problems facing the Navy in the mid-to-late 1970's, and why NARDACs were created, the reader is referred to Lambert (1982).

B. FORMULATION AND PURPOSE

The Navy for many years has espoused a philosophy of centralized policy and decentralized management and operation. In the majority of cases, this concept appears to be a viable one that suits numerous major Navy commands and their resulting functions. In some areas, however, and in particular in nontactical DP, the concept appeared to be less than satisfactory (O'Brien, 1978). Persistent problems in the management and operations of the Navy's nontactical DP program led to the establishment of a series of NARDACs to serve the Navy's nontactical DP needs (Scott, 1983; McAdams, 1984).

There are currently seven NARDACs, located in Washington, D.C., Norfolk, Jacsonville, Pensacola, San Francisco, San Diego, and New Orleans. These seven NARDACs control approximately 25-30% of the Navy's DP assets and are controlled and coordinated by the Naval Data Automation Command (NAVDAC) located in the Navy Yards in Washington, D.C. (Scott, 1984).

The NARDACs are designed to provide a full range of DP services to their respective geographic areas. The primary purpose is to provide the Navy with "centers of excellence" that will be able to provide DP services, programming support, technical expertise, trouble shooting, telecommunications networking, distributed processing, and other related DP services. Through the NARDACs, the Navy has economically brought time-sharing services in house, promoted standardized computing systems and application programs for a variety of of Naval activities, and offered automation alternatives to smaller activities not now utilizing a computer's capabilities (NAVDAC, 1986).

Included in the NARDAC support are a series of smaller DP service facilities called Navy Data Automation Facilities (NAVDAFs). The NAVDAFs are satellites of the larger NARDACs. NAVDAFs were established to broaden the scope of the Navy's DP support. NAVDAF sites are located in such areas as Corpus Christi, Newport, Great Lakes, Orlando, and Pearl Harbor to name a few. NAVDAFs provide on site support to major Navy commands and activities having special DP requirements in areas not otherwise supported by a NARDAC (NAVDAC, 1986).

The NAVDAC/NARDAC/NAVDAF organization is specifically designed to work together as one community in providing DP services to a myriad of clients. With scores of external customers, a NARDAC can be likened to a computer service bureau in the commercial world. The comparison breaks down, however, when the respective motivations for existence are compared. A commercial service bureau is in business to make a profit. A NARDAC's sole purpose is to provide a non-profit DP service to operational customers. Therefore, a NARDAC might better be compared to the information services department of a large business conglomerate instead of a service bureau.

C. ORGANIZATION

Though geographically separate from one another, each NARDAC was organized under a standard structure patterned after its parent NAVDAC. For example, NARDAC San Francisco consists of the office of the Commanding Officer, the office of the Executive Officer, the office of the Technical Director, and a Liaison Planning Staff Support Office. The following departments complete the structure: (1) the Management Support Division (Code 20); (2) the Technical Support Department (Code 30); (3) the Data Processing Programming Support Department (Code 40); and (4) the Data Processing Installation Department (Code 50). Figure 1 depicts a

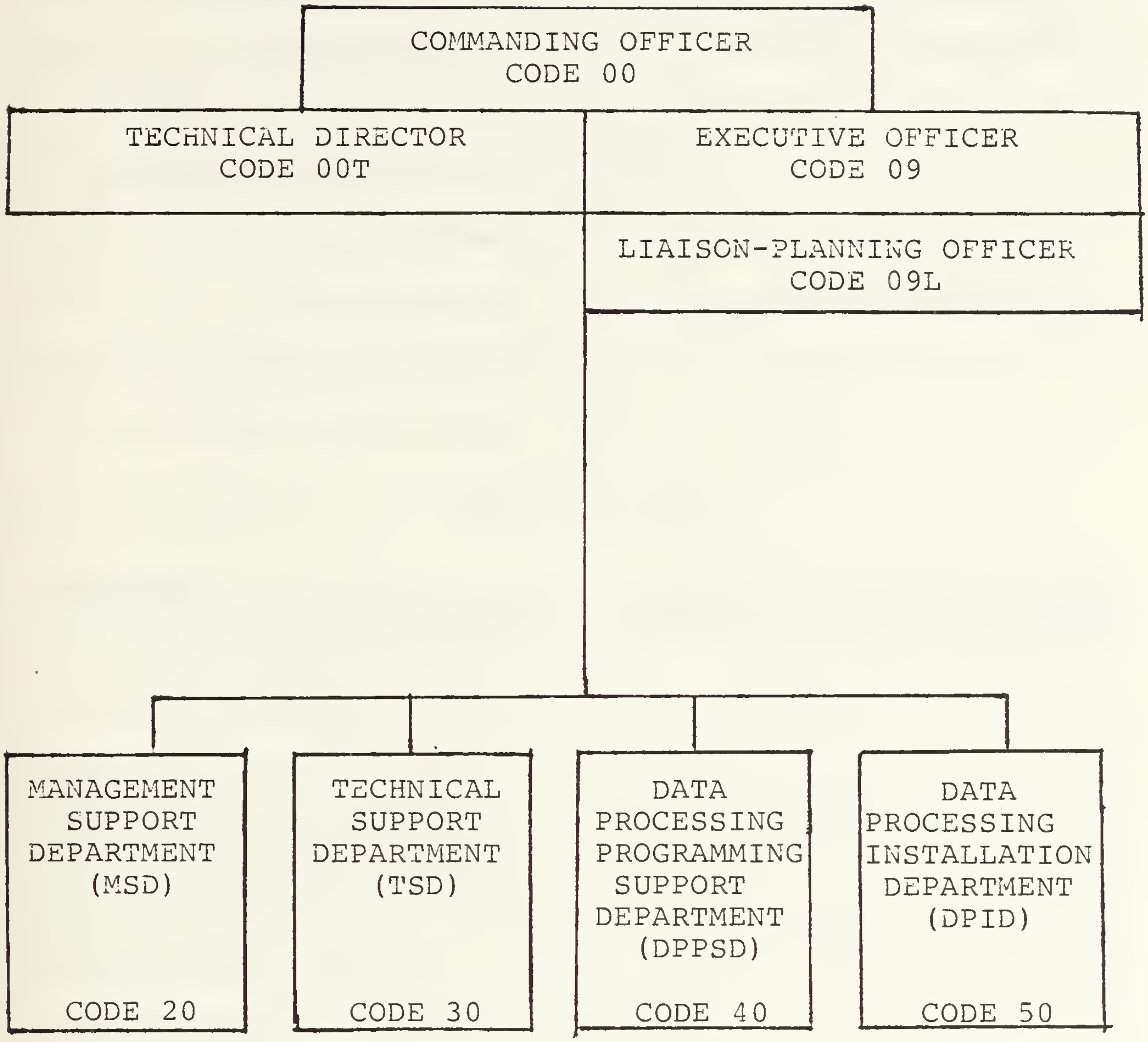

Figure 1 Typical NARDAC Organizational Structure

Source: U.S. Naval Data Automation Command. "The General Overview," NAVDAC Regional Data Automation Services. v. 1, 1986, p. 13.

MANAGEMENT SUPPORT (CODE 20)

* Budget and Accounting
* Management Services
* Training Coordination
* Physical Security and Facilities Management

TECHNICAL SUPPORT (CODE 30)

* Standards and Procedures
* Systems Software Programming
* Teleprocessing Networking and Configuration Planning
* Performance Analysis and Measurement
* Advanced Technical Studies
* ADP Security Technical Assistance and Consultation

DATA PROCESSING PROGRAMMING SUPPORT DEPARTMENT (CODE 40)

* Client Requirements Analysis
* Client ADP Systems Analysis
* Client ADP Application Programming and Documentation
* Technical Assistance and Consultation

DATA PROCESSING INSTALLATION DEPARTMENT (CODE 50)

* Computer Operations
* Acceptance Testing and Recovery Support
* Teleprocessing Operations Support
* ADP Production Control
* Data Libraries in Magnetic Media
* ADP Risk Management Technical Assistance and Consultation

Figure 2 Typical NARDAC Departmental Responsibilities typical NARDAC organizational structure. The major responsibilities of the departments within a NARDAC are depicted in Figure 2.

D. USERS

Almost all the NARDAC facility users are operational forces and staffs. Figure 3 displays a few of the major users of a typical NARDAC, broken down by reimbursable and mission-funded customers (i.e., Navy Industrial Fund (NIF) or Operational target (OPTAR) funded).

NARDAC XXXXXX
FY 19XX BUDGET

COMMAND	DOLLARS
NAVAL AIR REWORK FACILITY, XXXXX	XXXX
NAVAL AIR LOGISTICS COMMAND	XXX
NAVAL SEA SYSTEMS COMMAND	XX
NAVAL COMPTROLLER	XX
PACIFIC MISSILE TEST CENTER	XXX
REIMBURSABLE SUBTOTAL	XXXX
COMMANDER NAVAL AIR FORCES, PACIFIC	XXX
COMMANDER NAVAL SURFACE FORCES, PACIFIC	XXX
NAVAL AIR STATION, XXXXXXX	XXXX
NAVAL STATION, XXXXXX	XX
MISSION-FUNDED SUBTOTAL	XXXX
TOTAL	XXXX

Figure 3 Typical Users of a NARDAC

III. BASIC OVERVIEW OF A CHARGEBACK SYSTEM

A. INTRODUCTION

In this chapter, the fundamental theory underlying a chargeback system is broken down into its individual components and each component explored and discussed. By using an approach of this nature, it is hoped the the reader will more readily grasp the academic theory and reasoning behind the implementation of a chargeback system.

B. ESTABLISHMENT OF MANAGEMENT GOALS

A chargeback management control system is a process, or more precisely a set of processes, through which an organization attempts to ensure that actual data processing activities conform to planned activities (Cash et. al., 1983). A chargeback management control system must, therefore, be a dynamic entity capable of responding to and causing response from users to the dynamic goals of the organiztion (Bernard et. al., 1977). Moreover, the chargeback control system must be sensitive to the changing demands of DP users (Popadic, 1980). In addition, it must provide a framework for both efficient and effective resource utilization in a climate of future planning and current organizational performance monitoring (McKell et. al., 1979).

To be an effective information supplying mechanism for management control, a chargeback system must ultimately answer the question: "How are we doing?". The answer to the question encompasses not only the organization's financial health, but also: DP output or production performance, and progress toward the organization's overall long-range plan (Cast et. al., 1983). Acting within the framework of a management control system, the chargeback model is nothing more than a measurement system. Therefore, to be effective at measuring, a chargeback system must possess the following attributes: a feedforward mechanism (ex ante) for development of DP policy and procedures; and a feedback system (ex post) that continuously monitors DP management's progress toward attainment of the overall organization's goals (Flamholtz et. al., 1985).

C. OBJECTIVES OF A CHARGEBACK SYSTEM

Typically, as alluded to in Chapter I, the motivation for implementation of a chargeback system results from a desire to achieve one or all of the following objectives (Popadic, 1977; Kekic, 1980; Bernard et. al., 1977; Schaller, 1974; McFarlan and Nolan, 1975):

(1) cost recovery;

(2) effective allocation of computer services and products;

(3) regulation of demand for computer services and products.

Basically, the desire to recover costs originates from entrenched cost accounting and reporting conventions for evaluating performance. The objective of effective allocation of computing resources stems from the perspective that computer resources are scarce and, as such, priorities must be assigned to the application having the highest utility (Ein-Dor and Jones, 1985). Closely aligned with this concept is the concern for regulating demand. Some form of demand regulation is needed in order to ensure that computer resources are not overtaxed during some periods, and underutilized at other times (Ein-Dor and Jones, 1985). Ultimately, demand regulations exist to constrain users to demand services within the organizationally chosen level of DP resources available (Ein-Dor and Jones, 1985).

Clearly, management's motivations and objectives in charging for computing services and products will vary from one organization to another. Nevertheless, as stated above, the primary objectives are typically all related in some fashion to controlling the organization's computing activity. Simply stated, a chargeback system charges users for the processing costs of their application systems. This permits the users to make a "judgement call" as to whether or not their application systems should be modified, replaced, or dropped entirely. Therefore, a chargeback system encourages users to cost justify their use of DP products and services (Bernard et. al., 1977 ; Davis and Wetherbe, 1980). Implicit within chargeback theory is the assumption that by controlling DP products and service usage through chargeback, wasteful applications are eliminated, the efficiency of the remaining applications are increased, and the development and implementation of new cost justified applications are stimulated (Nolan, 1977; Brandon, 1978).

More to the point, organizations have historically implemented chargeback systems with an eye toward the accomplishment of some, if not all, of the following (Schechinger, 1983):

(1) improvement of DP cost control;

(2) increase DP efficiency;

(3) increase the users' awareness of DP costs;

(4) cause users to critically evaluate their DP requirements based on the economic value of the requested product or service vis-a'-vis the cost. For example, critically evaluate the cost of producing a report against the value of the report in a decision making process.

(5) recovery of DP costs;

(6) effective allocation of computer resources and the encouragement of central processing unit (CPU) load leveling, by charging a premium for jobs requiring a high priority or offering a discount for lower priority jobs.

The degree of realization of chargeback system objectives and the chargeback algorithms selected to attain those objectives implicity define management's philosophy and objectives regarding the role of DP in the overall organization. (Bernard et. al., 1977; McFarlan and Nolan, 1975). Basically, chargeback can take one of two approaches: the cost approach; or the pricing approach. The distinction between the two approaches involves both economic and accounting theory. The basic argument appears to be: should an organization disassociate the price charged for a computer resource from the total cost of operating the resource (Rizzuto and Rizzuto, 1978)? For example, McKell et. al. (1979) state that the cost approach motivation is mainly one of seeking to recover the cost of computing services. The price approach, on the other hand, considers the demand for resources to be of importance in coordinating the availability and allocation of computing resources in both a rational and effective manner.

It should be noted, however, that there need be no direct lock-step relationship between the cost of providing a computer product or service and the price charged the user for that product or service (Rizzuto and Rizzuto, 1978). The price for a service or product assuming a purely competive marketplace is based on the demand for that product or service. In theory, the more demand exceeds supply, the higher the price. Conversely, again in theory, the more supply exceeds demand, the lower the price. However, if price drops below the cost to produce a given service, that particular service will not be provided. At the point where demand equals supply, cost will equal price. This is commonly called the supply-demand equilibrium point in economic textbooks (Ein-Dor and Jones, 1985).

This begs the question of what constitutes "price"? Strictly speaking the computer center costs relevant to any specific decision on resource usage are the marginal, or incremental, costs of the resources involved (Ein-Dor and Jones, 1985). For example, in deciding whether to implement a new computer application, the costs that need to be considered in relation to the anticipated benefits are the incremental costs of providing the resources required for the new system. Thus, if users are to be led to make economically sound decisions on the basis of the chargeback system charges, those charges need to reflect the incremental cost of the associated resources (Ein-Dor and Jones, 1985). It is awfully hard for the typical user to discern incremental charges in this context. Nevertheless, it is clear that the incremental costs of resources will not necessarily equate to the average unit costs calculated through conventional cost accounting procedures (Ein-Dor and Jones, 1985). Given the economics of scale normally associated to mainframe computing, incremental costs will be lower than the prices required to fully recover the cost of the computer center (Ein-Dor and Jones, 1985).

The Office of the Comptroller, Navy (NAVCOMPT) has interpreted the Navy Industrial Fund (NIF) accounting rules and procedures to mean that NARDACs can only charge a user the actual (ie. the accounting) cost of running his application. Therefore, a lock-step relation between cost and price is assumed by NAVCOMPT. Because of the NAVCOMPT interpretation, NARDACs fall prey to the following argument advanced by Singer et. al.:

> If demand for a good is low, its price may well fall below cost, transmitting information to the producer that demand is inadequate. Unless price is permitted to fall below cost, the proper information about demand may never be obtained, and the allocation of resources can never adjust properly to the unprofitability of that good (1968, p. 494).

It should be noted at this point that a price structure designed to reflect full resource cost recovery will not necessarily always provide the appropriate basis for guiding user decisions on computer resource usage (more about this later). Suffice it is to say at this point that the emphasis in charging should be on controlling users' overall demands for computer resources, rather than based strictly on the recovery of hardware resource costs (Ein-Dor and Jones, 1985).

The following chargeback systems (or techniques) have been gleaned from chargeback literature and appear to be the more widely used systems and therefore, the most appropriate for further discussion.

D. ACCOUNTING SYSTEM USED

Just as there are several different goals and objectives that a chargeback system seeks to attain, there are several methods of accounting for DP products and services. The choice of a type of accounting system to employ is admittedly made on the basis of considerations more involved than merely the desire to attain a specific chargeback objective and/or organizational goal (Wiorkowski and Wiorkowski, 1973; Schaller, 1974; Cortada, 1980). Nevertheless, employment of certain types of chargeback systems facilitate the attainment of some objectives and goals but not others.

1. Free Good

The simplest approach to a chargeback system is not to have one at all. Under this system, computer products and services are treated as a free good. All DP costs are accumulated in various overhead accounts and treated as administrative costs. Problems with the free good approach are:

(1) No method to ensure that only cost effective applications are run on the computer system (McKell et. al., 1979).

(2) No method to ensure that efficient programming techniques are employed in development of application programs (McKell et. al., 1979).

(3) Resource allocation is made by arbitrary administration rules (ie. political clout) or by placing undue pressure on computer operators and management (ie. arm twisting) (McKell et. al., 1979; Dearden and Nolan, 1973).

(4) Perpetual computer saturation, so that DP management has no clear idea as to when additional capacity should be installed (Nielsen, 1968; McKell et. al., 1979).

Users in a free good environment often are encouraged to automate applications which are more economically performed by manual means (Schaeffer, 1981). In addition, once a user gains access to DP services, he more or less feels that he has a vested right to continue to use the services as long as he wishes (Schaeffer, 1981). Therefore, a user may automate some jobs that will later exclude more deserving applications from automation because of the perpetual saturation problem.

2. Full Cost Systems

Probably the easiest chargeback system to develop, implement, and operate is the full cost method, or sometimes referred to as the average cost method. Under this method, the total cost of operating the computer facility is divided by total utilization to produce a flat rate stated in dollars per hour. The operating costs and utilization rate are forecasted for the next period (weekly or monthly) to produce the next period's prices (Schaller, 1974). In some organizations, the actual costs are used and the rates and charges are determined retroactively (Schaller, 1974).

A major problem with the full cost approach according to Schaller (1974) is maintaining charge stability. As utilization of the computer increases, the rate to be charged decreases because of the large amount of fixed costs as compared to variable costs. The problem with decreasing rates is that users are encouraged to demand more products and services, and because of limited computer capacity capacity, turnaround time goes from acceptable to completely unacceptable. On the other hand, a decrease in utilization causes the opposite spiral to happen. As usage goes down, rates go up, driving usage down further and rates up higher.

Unless corrections are made it is possible for a customer under the full cost method to use fewer computer products and services and have an increase in his charges (ie. assuming total computer utilization also decreases).

Because the rates reflect all the costs of the service provided, the full cost method supplies very good quantitative information for a project costing, cost-benefit analysis, and profit efficiency evaluation (<u>EDP Analyzer,</u> July, 1974; Dearden and Nolan, 1973). Therefore, the full cost method successfully attains the objectives of cost recovery but only in a general sense. If a user has no funds, he gets no service.

When users pay a flat rate for services, regardless of when they are requested, there is no incentive to request services during non-peak periods (Schaller, 1974). This may lead to bottlenecks and slow turnaround times during peak periods (assuming the computer is operated for short periods beyond its capacity), while night and weekend shifts may be underutilized.

Using a longer time frame for determining rates will increase the variance from actual costs but decrease the rates fluctuation problem. Setting rates for a year period is standard costing.

3. <u>Standard Cost Systems</u>

The standard cost method charges users a non-fluctuating standard cost per unit of usage. By setting the rate at the beginning of the year and not changing it, the DP organization is encouraged to keep costs to standard (Popadic, 1975). Variances between actual and standard can be used to evaluate the DP organization's efficiency (Davis and Wetherbe, 1980). Some costs, however, particularly those due to volume considerations, may be beyond the DP management's control (Popadic, 1975). By analyzing the variances, the reason for cost growth can be pinpointed by comparing the fixed standard costs to the actual charges (Davis and Wetherbe, 1980).

The non-fluctuating rate eliminates the two major disadvantages of the full cost method. Standard rates do not change, allowing users to more accurately plan their DP costs for the accounting period. Theoretically, the user can depend on a job costing the same each time it is run (Popadic, 1975). Moreover, prices do not rise in a period of low demand. Therefore, computer under utilization will not be compounded.

There are disadvantages with the standard cost method, however. First, the rates will not reflect upgrades or improvements in the system until the end of the accounting period when the charges are reviewed. Second, at any one point in time, users' demand for computer products and services may exceed computer capacity. Standard costing provides no impetus for establishing priorities, or for running jobs in non-peak periods. Third, choosing a chargeback algorithm for standard costing can be difficult, because no algorithm accomplishes all the desirable chargeback objectives (Popadic, 1975).

In an attempt to eliminate the peak load problem, many organizations have adopted a variation of the standard cost method by introducing lower rates during non-peak periods. In addition, surcharges are applied for high priority jobs. This strategy has proven somewhat successful, particularly among users of batch processing, in smoothing out workloads between shifts, and lowering the number of high priority jobs (Popadic, 1975).

4. Flexible Price Chargeback Systems

If control of computer resources is the primary concern of management, flexible pricing should be employed. Rather than basing user charges on rates determined by cost, charges in a flexible price system are based on the economic value of the resource used (Ein-Dor and Jones, 1985). The *EDP Analyzer* describes it thus:

> If some resource is constrained in the amount that can be obtained, then it is priced according to its economic value, not according to its cost (November 1973, p. 6).

An important aspect of flexible price chargeback systems is the value placed on differences in levels of service. Service is usually defined in terms of turnaround time. Therefore, prices can be set for several different service levels. For example, Level I, turnaround time of one hour; Level II, turnaround time of two hours; Level III, turnaround time of five hours, and so on.

A second important aspect of flexible price systems concerns resource congestion. If congestion during particular shifts is a problem, flexible pricing can be used to effectively smooth out the peaks. By making the price of resource usage an increasing function of time, or memory volume during busy shifts and a decreasing function of time or memory volume during under utilized shifts, users will be strongly motivated to run long batch jobs during slack periods (Schaller, 1974).

Flexible price chargeback systems, if properly implemented and operated, can be used to attain many of the objectives of a chargeback system (Dearden and Nolan, 1973). The primary disadvantage of flexible price systems are that they are expensive, involve vast amounts of overhead, are complicated, and thus complex to administer.

In summary, many factors should be considered in choosing a cost allocation technique. Management must clearly define its objectives for the DP organization and choose the chargeback algorithm (allocation technique) and base which best serves these objectives (McFarlan et. al., 1973; Bernard et. al., 1977).

D. CHARGEBACK SYSTEM PERFORMANCE CRITERIA

A number of authors propose performance criteria that a chargeback system "should meet". The following selection points out the wide diversity of proposed performance criteria. For example, Wiorkowski and Wiorkowski (1973) recommend that a chargeback system be equitable, reproducible, and realistic. Bookman (1972) offers accuracy, repeatability, understandability, and competiveness. Kekic (1980) states that the chargeback system should embrace all of the above criteria, plus be auditable, and recover all operating costs. (Kekic's performance criteria are defined and explored in more detail in Chapter IV). Hootman (1969) contributes the following to the list: user control; and demurrage (a user should be charged for resources made unavailable to other users). The opinion of many more authors could be listed, but these should be sufficient to make the point: there are many possible criteria that a charging system could meet. It is management's responsibility to decide just which ones chargeback should meet in order to attain the desired objectives of the organization. A more comprehensive study of this point is provided in Chapter VI.

The desirable chargeback criteria should follow from the goals and objectives of the chargeback system as defined by top management. In general, the basic objective is to influence DP and user behavior in support of organizational goals. In order to do this, all parties concerned must believe that the system is basically a fair one, taken seriously by top management, and above all, part of the overall planning and control structure of the organization.

IV. NAVY REGIONAL DATA AUTOMATION CENTER CHARGEBACK SYSTEM

A. INTRODUCTION

The Naval Data Automation Command (NAVDAC) is an echelon II command of the Chief of Naval Operations (OPNAV). It consists of a headquarters staff located in Washington, D.C. having echelon III and IV DP support field activities known as Navy Regional Data Automation Centers (NARDACs) and Navy Data Automation Facilities (NAVDAFs). NAVDAC, the NARDACs, and NAVDAFs were formed as a result of the Navy Automated Data Processing Reorganization Study and Implementation Plan of 1976. The motivating force was a need to improve the management and operations of the Navy's mission support DP program (Scott, 1984).

Before the reorganization, DP support was provided on a no-charge basis by Data Processing Service Centers (DPSCs) (O'Brien, 1978). The Office of the Chief of Naval Operations (OP-91) at the time of the conversion of DPSCs to NARDACs stated:

> The performance and economic benefits attainable from a DPSC are not likely to be realized if its services are furnished free of charge. The center should be operated on a fully reimbursable basis. Total costs of operating the center (salaries, equipment rentals, supplies, etc.) should be reflected in a billing and accounting system which permits customers to be billed promptly for all fair and accurate services received. This procedure will allow all DP support costs to be related directly to both customer activity and the function supported. (NAVDAC, 1978)

NARDACs are located in most regions of extensive Navy activity. The smaller satellite NAVDAFs operate at other large Naval installations. Teleprocessing brings NARDACs to many more remote Navy commands requiring DP services.

Comptroller of the Navy (NAVCOMPT) regulations provide a conventional Navy financing basis for user (client) command/NARDAC support arrangements. Additionally, NAVDAC requires the use of standard annualized rates for different types of support rendered at each NARDAC. To determine these rates requires the use of the NARDAC chargeback system. This standard cost chargeback system, operating at all NARDACs, is used to provide monthly user statements of charges and is the subject of the remainder of this chapter.

B. BACKGROUND

A 1975 General Accounting Office (GAO) report on Navy DP was exceptionally critical. The report stated that the Navy's DP was unstructured; highly decentralized; had lax enforcement; had too much local prerogatives (i.e., too many local commands with unique, one of a kind, DP systems augmenting standard Navy systems); and had extensive duplication of Central Design Agencies (CDAs) and programmers (Cullins, 1978). As a result of the GAO report along with increasing pressure from the Assistant Secretary of the Navy for Financial Management (ASN(FM)), the Department of the Navy's senior nontactical DP policy official, the Navy developed a DP Reorganization Plan in 1976.

As part of the overall reorganization plan of the Navy's nontactical DP resources and management, NARDACs were designed, located, and staffed. The NARDACs were formed from existing facilities and operations in geographical areas of which the former DPSCs formed the nucleus.

C. MANAGEMENT POLICY AND OBJECTIVES OF THE SYSTEM

NAVDAC's mission is to administer and coordinate the Navy nontactical DP program. This responsibility includes collaboration of DP matters with all Navy DP major claimants; development of policy and procedures; approval of systems development, acquisition, and utilization of DP equipment and service contracts; sponsoring of DP technology; and career development and training of DP personnel (McAdams, 1984). For a more comprehensive and indepth discussion of the NAVDAC and its evolution, the reader is referred to McAdams (1984) and Lambert (1982).

NAVDAC's principal policy is to improve the effectiveness of DP systems in support of Navy operations, to exploit all the potentials of DP teleprocessing technology in multi-command and multi-functional DP systems, and to improve the overall management of the Navy's DP resources (Cullins, 1978).

Perhaps if a single statement could serve as the ultimate policy for the NAVDAC/NARDAC complex, that statement would be "quality nontactical DP support service". Quality nontactical DP support service to Department of the Navy users (clients) in support of existing applications and DP projects planned and underway (Roth, 1986).

The primary objectives of the NARDAC chargeback system are (NAVDAC, 1978):

(1) improve DP cost accounting;

(2) increase the DP activity's efficiency;

(3) provide for scare DP resource rationing;

(4) make the user aware of the cost of DP.

NAVDAC/NARDAC policies, objectives, and future were perhaps best summed up in statements made by Captain Michael Roth, USN, Commanding Officer of NARDAC San Francisco. Captain Roth stated that the NARDAC's are not the Navy's total or final answer to DP by any means. They do, however, represent a sound step forward and form a firm foundation from which to launch other NAVY DP initiatives. The long-range goal of the NAVDAC/NARDAC complex is to improve the management and operations of the Navy's DP resources. The impetus is the provision of improved DP services in support of expanding Navy missions and responsibilities.

D. PERFORMANCE CRITERIA

To meet the challenges of efficient and effective support and overall management improvement of the Navy's nontactical DP resources, a chargeback system was developed and implemented that espoused the following performance criteria (Kekic, 1980; Thompson, 1986):

(1) ACCURACY--The system should accurately compute customer charges.

(2) REPEATABLE--The cost of a job must not be contingent on computer system load or computer system. For example, it should not cost more to run a job on computer system A than it does on computer system B.

(3) UNDERSTANDABLE--With minimal training, the user should be able to determine how the charges for his job were computed and reported.

(4) EQUITABLE--All charges should be based on usage data gathered by the chargeback system's algorithm, with each user billed only for computer resources used.

(5) PROMOTE EFFICIENT USER OF HARDWARE--The chargeback system should encourage users to use computer resources efficiently.

(6) AUDITABLE--Outside sources should be able to track each billable charge from its source to its proper use (i.e., birth to grave).

(7) COST RECOVERY--The system, in order to operate effectively, should be capable of recovering the cost of computer resources.

E. BILLING ALGORITHM AND RATE DETERMINATION

The NARDAC chargeback system provides for ongoing measurement of resource usage by each user. It is designed to provide an equitable and accurate method for charging DP costs to a resource pool consisting of nine hardware systems and one labor pool. Individual rates are established for each measurable component of the resource pool to allow for equitable cost recovery from each user based on the individual users' application (Howard, 1986). Users of the resource pools are charged their proportional share of these costs through the use of a billing algorithm. The billing algorithm develops an account charge (AC) by transforming resource usage into the equivalent costs in terms of ADP resource units (ARUs). ARUs represent the total cost of producing the DP product or service in a Navy Industrial Fund (NIF) environment (Kekic, 1980). The use of pooled rates allows for equal distribution of DP resource costs to all users based upon usage (NAVDAC, 1978). Figure 4 is an example of the NARDAC chargeback billing algorithm.

The billing algorithm is designed to capture all costs directly associated with the computer facility. These costs include (Thompson, 1986):

(1) accelerated civilian labor costs up to and including first line supervision;

(2) rental of computer equipment;

(3) supplies and materials;

(4) maintenance of equipment;

(5) utilities;

(6) tape librarian and schedulers labor;

(7) user specific military programmer and civilian programmer labor.

Costs excluded from reimbursement include (Thompson, 1986):

(1) second and higher level supervision;

(2) general and administrative expense (e.g., supply and comptroller personnel);

(3) building maintenance and depreciation.

$$AC = \left[\sum_{j=1}^{k} AFj \left(\sum_{i=1}^{n} Uij * UCi \right) \right] + (TD * UCFs)$$

AC = Account Charge

k = Total jobs run using computer resources

AFJ = Run Category Adjustment Factor. Jobs are charged from 10 to 1000 percent of the basic job charge depending on their priority and time of day they ran. The index (j) varies from 1 to k to include all jobs run using resources.

n = Total resources used for a job. The index (i) varies to include all resources used for a particular job. Values of i represent CPU time, memory time, cards read and punched, pages printed, etc.

Uij = Utilization of resources i by job j in appropriate units.

UCi = Unit Charge rate for resource i.

TD = File space assigned to the account in track days.

UCFs = Unit Charge for File Space.

Figure 4 The NARDAC Chargeback Billing Algorithm. Source: R. Kekic, "ADP Chargeback System", <u>ACCESS</u> v. 3, January-February 1980, p. 29.

It should be noted that the cost charged the user by the NARDAC chargeback system billing algorithm is based on the cost of providing the DP product or service, not upon the value to the user receiving the service. In the opinion of the Head, Budget Policy Counsel, NAVCOMPT all charges to user activities must reflect the actual charges incurred (Scott, 1983). Therefore, neither priority nor shift differential prices are allowed, because they are based upon the economic value of the products and services, not the actual cost of providing them. Thus, the objective (refer to Chapter III) of cost recovery can be met by NARDAC chargeback system; but the objectives of computer resource allocation, and demand regulation cannot be met. Consequently, an extremely important economic feature of chargeback is negated by current NAVCOMPT interpretation of cost charging regulations.

If computer resource allocation is an objective, a system that allows for shift and priority pricing (i.e., differential pricing) must be used. The EDP Analyzer summarizes this point well in the following statement:

> Data processing management should look beyond charging as simply a means of cost recovery. Every charging system influences user behavior. To make them work at all satisfactory, they must be supplemented with other policies, such as priorities. (Flexible) prices can do all these things that these other policies do, and with the added advantage that the users make the allocation decision. (November 1973, p. 13)

The consensus of opinion in the chargeback literature reviewed by the author is that flexible price systems are superior for resource allocation and resource utilization to strict standard cost systems (EDP Analyzer, July 1974). A modified (or hybrid) standard cost system that allows for differential pricing would provide the user with a strong economic motive to run long and/or low priority jobs during slack periods when costs would be lower. This of course would require NAVCOMPT legal counsel to modify its decision regarding cost recovery in a NIF environment for DP cost recovery. Without an exception for DP cost recovery, it is this author's opinion that NARDAC's stated objectives to: provide for resource rationing, and increase the DP activity's efficiency cannot be attained.

F. PERFORMANCE EVALUATION

NARDAC users are concerned about meeting deadlines for scheduled jobs, receiving quick service for unscheduled jobs, fast response time for on-line jobs, service plagued with a few disruptions (i.e., reliable service), and when those disruptions do occur they are of short duration. The means for evaluating performance in these areas are now considered.

Each user receiving computer products or service from a NARDAC has a "level of service" agreement with the NARDAC (NAVDAC, 1986). There are up to five service level options for each type of processing interface between the user and the NARDAC. The user can negotiate the level that best meets his job and budget requirements. If so agreed, the NARDAC can provide production line processing, assuming responsibility for control and scheduling of each application that has undergone acceptance testing and turnover to the NARDAC.

Performance is evaluated by (Roth, 1986):

(1) the number of written or phone-in complaints received;

(2) comparing actual job performance to the level of service agreement standards;

(3) calling on the user periodically and investigating any problems uncovered during the interview;

(4) responses to a more formal periodic "satisfactory survey" conducted by the NARDAC in interview form.

Thus the goal of the NARDAC performance evaluation methods can be summarized as a method to measure performance. The direct benefits as expressed by NARDAC management and staff are (Thompson, 1986):

(1) awareness of degrading performance;

(2) resources are more fully utilized;

(3) data storage becomes more efficiently and effectively organized;

(4) makes application programs "in development" more efficient and less error prone (programmers are evaluted on the number of errors uncovered in testing).

V. PREFERRED CHARGEBACK OBJECTIVES

A. GENERAL OVERVIEW

Before preceding with this chapter, a brief summary of the points made and arguments advanced thus far is in order. Chapter III presented a basic academic overview of a chargeback system. Management goals and objectives of a chargeback system were discussed in a more or less generic manner. In the previous chapter, Chapter IV, the Navy Regional Data Automation Center (NARDAC) chargeback system was presented and the specific management policy, objectives and chargeback criteria of this operational system were discussed. The reader should note the close agreement between the NARDAC objectives and criteria and those objectives and criteria gleaned from chargeback literature and presented in Chapter III.

While the policies, objectives, and criteria needed to reach the objectives presented thus far meet the basic requirements of a management control system in a data processing (DP) management context; something is still missing. Something is still amiss, because the method by which DP services and products have been charged to the user community has historically not been satisfactory to managers at the user or DP executive level. The problem, essentially, is that there is a difference in perspective about the computer resource. This difference in perspective results in communication problems among DP executives (eg. the Navy at the OPNAV/NAVDAC level), user management (eg. at the Naval Air Rework Facility level), and DP management (eg. at the NARDAC level). Therefore, this chapter attempts to provide that "something else" that will hopefully bridge the communications gap between the various perspectives. The higher level objectives presented in this chapter and higher level criteria presented in Chapter VI are called for purposes of this thesis, preferred objectives and preferred criteria.

The preferred objectives and criteria were sifted from current and past literature on the subject of chargeback. The author in this chapter as well as the next tries to cement these selected ideas, along with some of his own, into a coherent framework so as to make them more understandable to the reader.

In order to present the preferred objectives in as meaningful an environment as possible, this chapter addresses two important aspects of DP management. First, a planning system for DP resources is discussed from the perspective of a chargeback system. Second, an operating system for DP operations is discussed from the same perspective. The two systems are then integrated into a synergistic framework that will, hopefully, offer more of an insight into how chargeback can be used as the formal economic communication system among DP executives, DP managers, and user management than what is currently available in chargeback literature.

B. INTRODUCTION

Since the labor and overhead expense of implementing, operating, and tuning a chargeback system can be significant, it is important to recognize the objectives of the system and the degree to which these objectives are in accord with those of the overall organization. While it is true, that management objectives in charging for computer products and services may vary from one organization to another, nevertheless, one primary objective of any organization using a chargeback system should be to increase its financial control over DP (Anderson, 1983).

Increased financial control can result in more efficient and effective utilization of computing products and services (Anderson, 1983). Since a chargeback system involves not only DP but the customers for whom the products and services are being performed, a chargeback system provides a mechanism whereby the user can be made more cost conscientious (i.e., more efficient). In addition, it can force the user to economically evaluate the value received against the cost of the service provided (i.e., become more effective) (Andersen, 1983). The user accomplishes his objectives by controlling his request for products and services, and by participating in price or cost negotiations with the DP organization

(Ein-Dor and Jones, 1985). Therefore, a second and perhaps just as important objective comes to the fore, that of user-DP organizational goal synchronization...the communication of DP organizational policy, user requirements, and DP standards.

How the DP organization, through the use of chargeback, attempts to attain its formal and informal objectives can have a direct effect on how the DP organiztion is viewed by the user community. Since the preferred objectives to be fulfilled are financial control of the computing resources, and user-DP organizational goal synchronization, chargeback is, therefore, tasked with the role of being the formal communication system for accomplishing the preferred objectives.

In controlling the financial aspects of DP. The primary problems faced by DP executives are determining how much to invest in hardware, software, and people, deciding which proposed computer system or upgrade should be implemented, and above all measuring the effectiveness of the DP organization (Schaeffer, 1981). In other words, the basic management control question condenses down to this: is DP providing the right service, in terms of capacity, performance, and reliability, and at the right price? One avenue at arriving at the "correct answer" to the question appears to lie in proper long-term planning. Therefore, the first part of this chapter argues that the development of a DP activity which supports the organization's goals and objectives (as discussed in Chapter III and IV) requires the development of a management control system consisting of two major parts or loops. The first is a viable planning system, and the second is a strategy for operational control. Chargeback literature discusses these two systems as though they were separate and distinct entities (Harril, 1965; EDP Analyzer, August, 1975; Mushet, 1985; Andersen, 1983). This author argues that both planning and financial control are vital and have to be treated as an integrated whole before a chargeback system can be operated effectively as a management control system. Planning in this context is not to be confused with strategic planning. The reader is referred to Chapter I and Anthony's definitions of managerial activities for a clear definition of the aspects of strategic planning and management control.

C. THE PLANNING SYSTEM

Top management, in setting the course (or direction) to steer for the organization, must be able to assess the productivity of the DP investment in support of that course. Fundamental to such evaluation is a DP plan with its key objectives articulated very clearly at the outset of the planning period (Nolan, 1977). Without clearly stated objectives, management lacks a basis to evaluate the effectiveness of the DP expense since there is nothing to measure against. It is essential, therefore, not only that the DP objectives be articulated in such a way which permits them to be tied to the overall objectives of the organization, but that they be quantified in a well documented plan to facilitate review and performance measurement against the plan.

In developing a DP plan, management must avoid the tendency to "plan a little in this area" (i.e., distributed processing) and "plan a little in that area" (i.e., database management). The development of a proper DP plan can be likened to building a ship. No shipyard would start to build a ship until it has been completely designed, for only then can the really hard questions be answered, such as: What will it cost?; How economical is it (i.e., how efficient)?; Will it float (i.e., how effective)?. Similarly, a carefully thought out, well quantified and documented DP plan will allow top management to answer the questions most commonly asked of DP, such as: What is this new and improved computer system going to cost?; Will it be more economical than the old version over the long-haul?; Can it be made to work as advertised?. Pouring funds and resources into unplanned DP systems is like embarking on a long cruise without the proper charts or even a compass. Any direction is as good as any other, since you do not know where you are at, or where you are going, or even if you are moving.

Operating a DP organization without managing its resources means making "seat of the pants" decisions and reacting to events rather than planning for them. In such an ad hoc operating environment, DP users are considered the source of existing applications, which make up the DP organization's workload. The job of a manager of this kind of DP organization is viewed as ensuring that applications are processed properly, timely, accurately, and that the results and costs are sent to the users. In this kind of an environment, a DP control system exists, but little if any planning for the future is done.

A slightly more sophisticated environment involves managing the hardware resources only. In this environment, the DP organization allows hardware availability to determine workload priorities and uses the production operating results to review hardware utilization. In other words, the emphasis is on the efficient and effective use of the hardware itself. Clearly, managing the hardware system is better than no control at all, but the DP organization is still only being operated, no real management or planning is taking place.

A proper planning system involves users, DP management, systems analysts, programmers, and computer operations personnel. Using the expected workload requirements generated by current and "in work" applications, and the users' projected future workload, DP management must review the use of the computer center's total resources (personnel, hardware, and software) in order to anticipate future resource needs. These needs are then converted into actual resources (Schaeffer, 1981).

When current resources appear inconsistent with anticipated future needs, management either must authorize significant and timely changes in the resource mix, or consent to a reduction in service levels. For example, staffing may be inadequate for the planned workload, in which case upper management may authorize the hiring of additional, or depending on the applications, specialized staff. If a significant increase is expected in on-line terminals, more hardware or software resources may be required to support the increase. These examples serve to illustrate the required up and down the hierarchy and across the interface communications that must take place among users, DP management, DP executives, programmers (systems and applications), and computer operations personnel in order to implement a viable planning system. The planning system loop is depicted in Figure 5.

D. THE OPERATING SYSTEM

User management and DP management also participate in the operating systems activities. When an application becomes part of the DP center's workload, a DP Service Agreement should be negotiated between the user and the DP organization (Rizzuto and Rizzuto, 1978). The agreement should indicate the expected volume of work for the

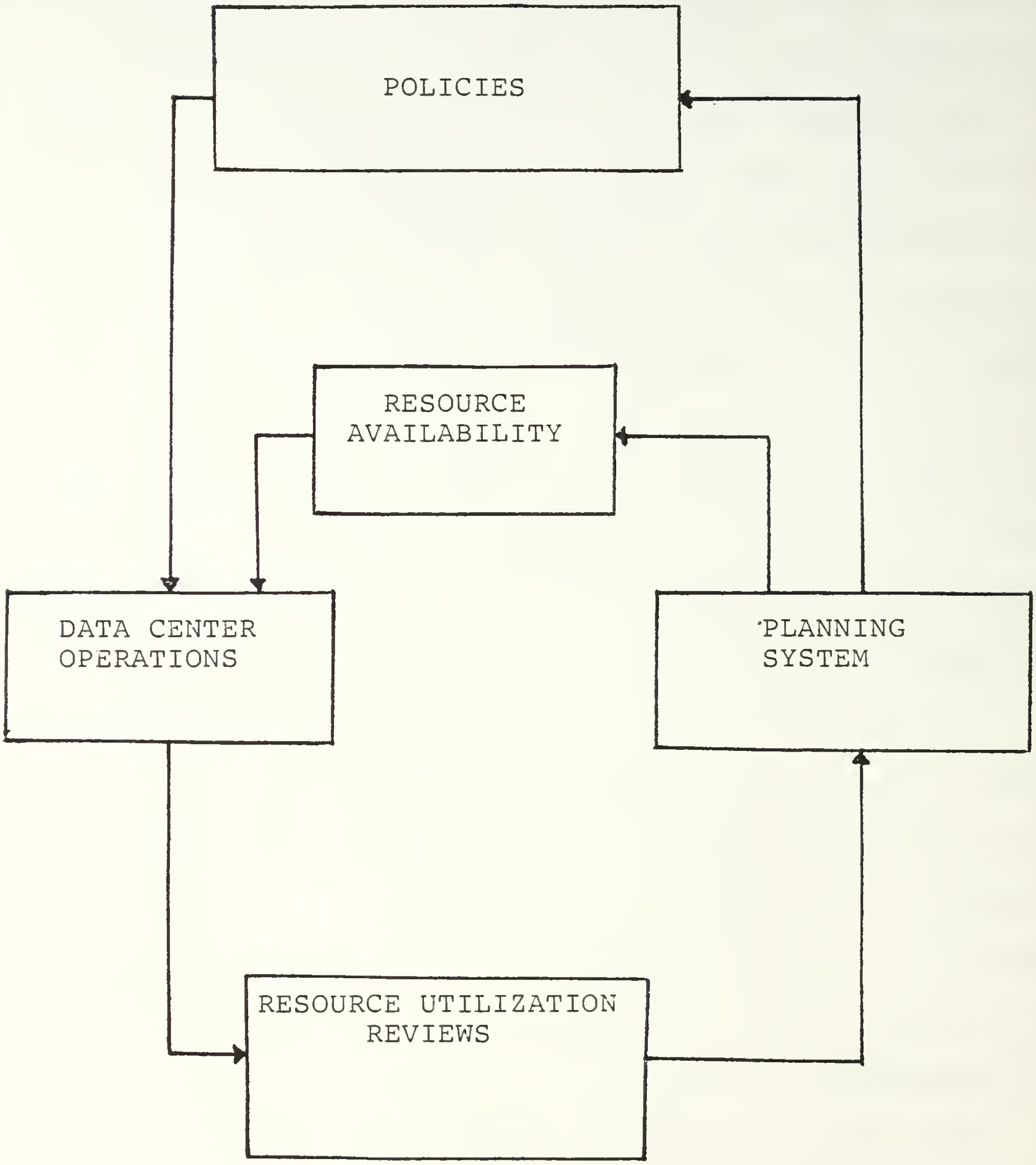

Figure 5   The Planning System Loop

application (e.g., the number of transactions to be processed each week, or the hours of peration for an on-oine system), the job priority, and the expected performance level (i.e., the delivery time for batch reports, or the availability hours for the on-line systems)(Cortada, 1980). Chapter VI provides an in-depth discussion of this important agreement. User management and DP management must review the operating results from the computer center regularly, comparing the results with the service agreement standards and noting any variances (Davis and Wetherbe, 1980). The operating system loop is depicted in Figure 6.

Setting standards and developing measures to those standards is much easier said than done. Chapter VI provides an in-depth discussion of the considerations that are necessary when setting chargeback criteria (standards). Chapter VII discusses the most current concepts and theories concerning the development and measures to standards.

E. PLANNING AND OPERATING SYSTEM CONGRUENCY

1. A Balanced Data Processing Center

To achieve a balanced DP center operation, the DP organization must use all resources effectively and efficiently and maintain communications with the user community. In order to attain such a balanced center, requires the implementation of a management control system that incorporates management of the operating system with management of the planning system. This framework is best characterized in

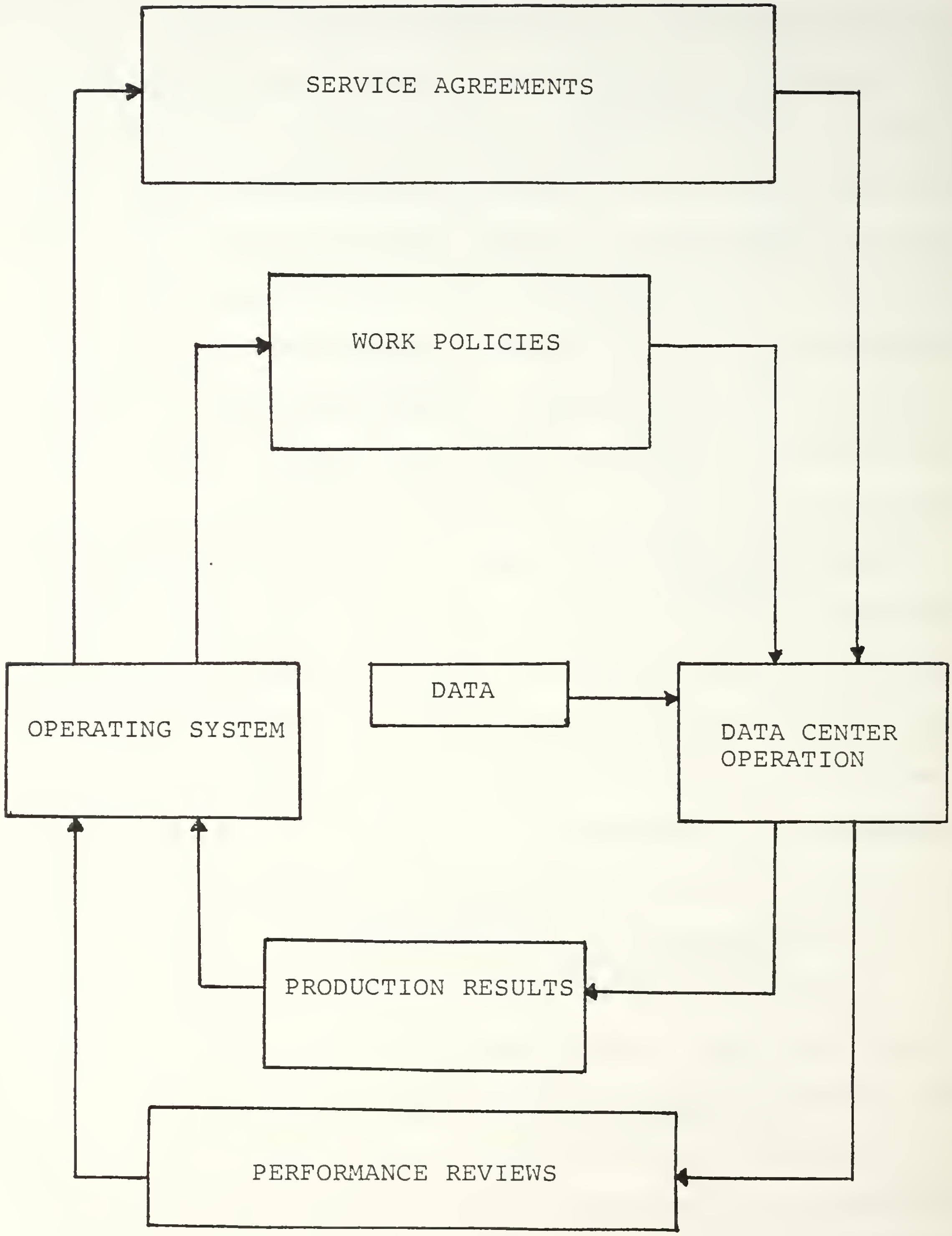

Figure 6 The Operating System Loop

terms of a planning system loop and an operating system loop as depicted in Figure 7.

The DP organization must manage the activities and maintain the necessary communications in both the operating system and the planning system. When the two systems are in congruence, users are active and informal participants, the DP organization is responsive to user needs, the total computer resource is put to efficient and effective use, and DP top management makes policy, not technical decisions about the level of resources available for serving the users (Rizzuto and Rizzuto, 1978). Operating in this type of environment requires a continual examination of the resource and service mix by the DP organization and open communications between users and the DP organization (Rizzuto and Rizzuto, 1978).

If the chargeback system is to be the formal economic communications system between the planning and operating system and among DP management, DP executives, and user management, then it must:

(1) Permit user management to prioritize applications make trade-offs and control their costs (Nolan, 1977).

(2) Enable DP management to provide and measure the service levels required by users (Rizzuto and Rizzuto, 1978).

The two necessary attributes for effective communications can be attained through proper financial control, and user-DP organizational goal synchronization.

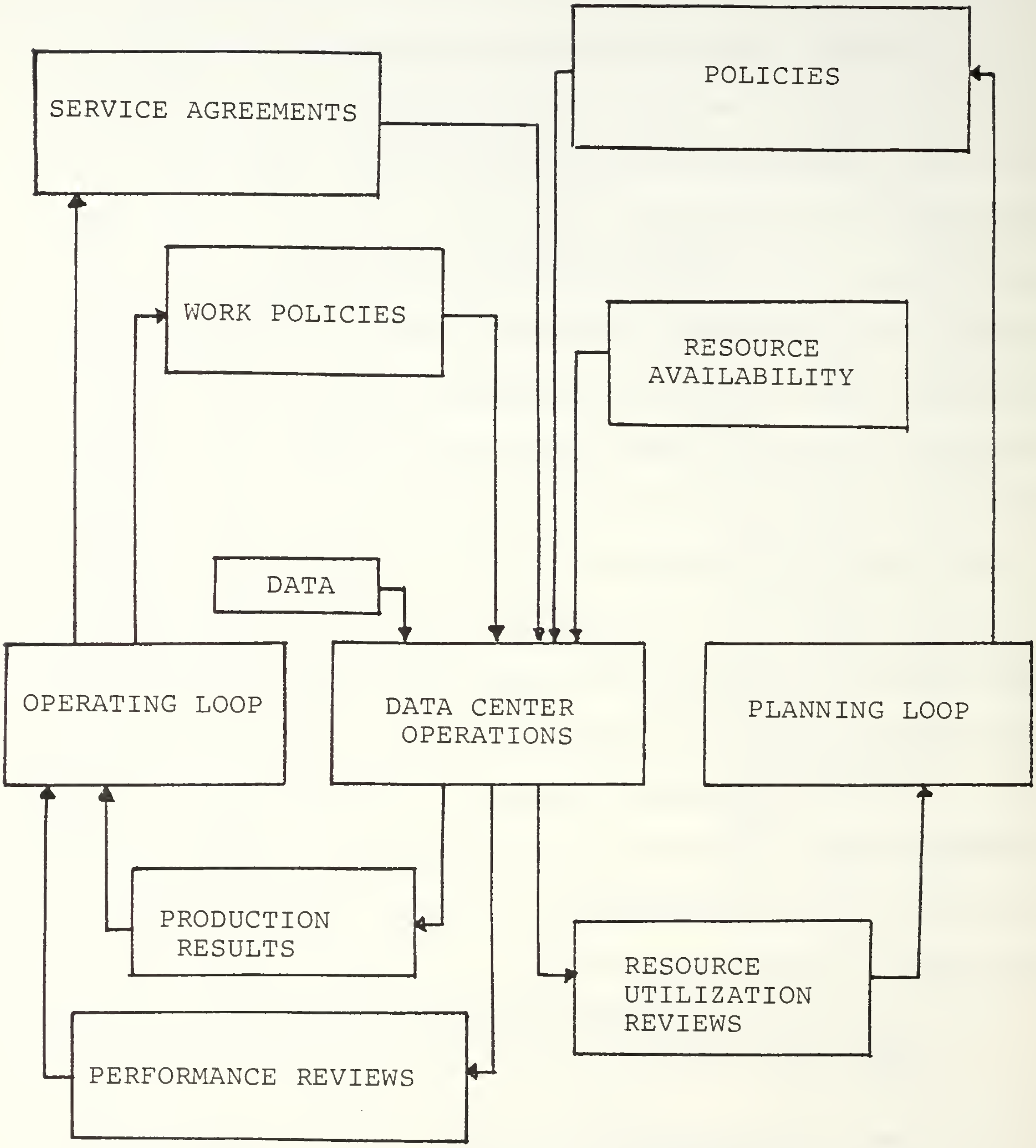

Figure 7 The Balanced DP Center

2. Financial Control

The first objective of a chargeback system should be financial control. Financial control can be satisfied in one of three ways. If some form of cost allocation is required with limited user cost control, a cost center is appropriate with centralized budgeting (Bernard, 1977). In this case price equals cost by definition. With centralized budgeting, the reader should note, however, that central or corporate management is paying the bill. The money used by organizations or departments to pay for computer services and products comes from a separate budget (Bernard, 1977). This is commonly termed in chargeback literature as the use of "funny money". From central mangement's perspective, it is real money. From the user department perspective, however, it is not real in the sense that it cannot be used for computer products or services outside the department or organization. Centralized budgeting is, therefore, merely a way of rationing.

A cost center with decentralized budgeting has much more of an impact on financial control. In this schema, the users pay for computer services and products out of a budget that can be used for products and services outside or inside the DP organization. As an aside, if decentralized budgeting is used and the user has little control over his cost or cannot reasonably estimate his future costs because of a poorly implemented or operated chargeback system; he will not be able to properly manage his business (McKell et. al., 1979).

The last type of financial control is a profit center. In this responsibility center (to borrow a term from Anthony), price can be a function of cost, or a function of cost and profit, or a function or whatever the market will support (Ein-Dor and Jones, 1985).

Decentralized budgeting (NARDACs are a typical example) can promote under or overutilization of computer resources. This fact begs the question: what is the relationship of user demand and capacity to price? In other words, how often does a user pay more for less? This question is significant, because it is what can happen in a DP chargeback environment unless management is astutely aware of the operations going on around them. There are three cases to consider:

(1) supply is equal to demand;

(2) supply is greater than demand;

(3) supply is less than demand.

The best of all possible worlds occur where supply just equals demands. In this situation cost (charges) will remain constant and predictable as long as the equilibrium situation prevails. Quite simply, users can be billed based on the average cost incurred in processing their jobs. Problems in billing begin to occur when supply exceeds demand or demand exceeds supply. In order to prevent the user being charged more for less computer services, the DP organization must ensure that the chargeback model has a rate determining structure that is an independent process from that of determining the optimal coefficients for the chargeback algorithms. While chargeback coefficient determination must precede rate setting, the objectives differ considerably. Rates are expressed as dollars per unit of utilization. Coefficients are used to establish the correct proportions among variables in each chargeback algorithm for different service types (e.g., batch processing time-sharing, and database processing) and for the same application running on different computers (i.e., the resulting cost of running the same application on two different computers is the same). The objective of rate setting is to adjust the levels of utilization, as computed by the chargeback algorithms, to fully recover the DP organization's costs (Davis and Wetherbe, 1980).

As previously stated, the rate structure must be independent of the algorithms used in chargeback. The algorithms convert utilization statistics into a measure of computer product and service utilization. The rate structure is used to convert the utilization statistics into dollar charges based upon a schedule of rates. The rate structure may include discounts for jobs executed on the night shift or on weekends. A surcharge may be levied for high priority jobs or jobs that require the locking of many I/O resources.

The rate structure must be examined at least annually to assure recovery of all DP organizational costs. In addition, the coefficients used in the algorithms that form the basis of the chargeback models must be reset annually. This is because acquisition of new equipment, software, and people affect the optimal values of co-efficients in the model. Therefore, a reoptimatization (or re-tuning) is called for at least annually to recalibrate relationship among the variables in each algorithm type in the chargeback model.

3. User-DP Organizational Goal Synchronization

The second preferred objective of chargeback is user-DP goal synchronization. The way to achieve this is through cost accounting effectiveness (Heilger and Matulich, 1985). To be effective, from a cost accounting standpoint, the chargeback system should indicate what problems are important. For example, if product or database reliability or performance is a problem, the chargeback system should highlight this fact. The typical chargeback system fails in a true cost accounting sense. It does not indicate what problems to look into. The only thing current chargeback systems provide is a strict measure of cost. Lehman (1973) provides an indepth study of one of the more popular systems, CASCOM. The emphasis in CASCOM is strict measure of cost.

Typically, the user cannot understand nor control his costs and, as a result, is dissatisfied with service. If left unchecked this dissatisfaction can lead to a lack of user involvement and sever DP/user communications. Some DP managers argue that the resulting problems are nothing more than problems in user perception, or a lack of proper training in the concepts of chargeback. Nevertheless, whatever the cause of the problems, it is the DP manager's responsibility to deal with them. The most effective means of solving the above kind of problems is to ensure that all measurements of cost presented to users be agreed upon by users and the DP organization before hand. The measurements should be couched in terms easily understood by computer illiterate users, the measurements should relate to the users' business, and the measurements should be controllable to some extent by the user.

F. CHAPTER SUMMARY

The main thrust of this chapter has been:

(1) a balanced DP organization requires a management control framework that incorporates both planning and operational control;

(2) the chargeback algorithms utilized in a chargeback model must provide independence of coefficients and rate structure;

(3) the chargeback system must permit differential pricing;

(4) the DP Service Agreement must include measurements and standards that are understandable and, to some extent, controllable by the user.

If the above four concepts are properly and carefully designed into the chargeback system, then the preferred objectives of financial control and DP-user goal synchronization are reasonably attainable.

VI. PREFERRED CHARGEBACK PERFORMANCE CRITERIA

A. INTRODUCTION

The concern about data processing (DP) deficiencies in the United States Government and industry is widespread. As stated in Chapter IV, the United States Government, one of the biggest users of data processing (DP), is very concerned. The investigative arm of Congress, the General Accounting Office (GAO), has examined and reported on the effectiveness of the Government's DP operations. In a GAO report entitled "Computer Auditing in the Executive Departments: Not Enough is Being Done," costly wastes resulting from inadequate control are mentioned. Anderson (1978) in an article commenting on some of these inadequacies, concludes that if some major corrective steps are not taken soon, it will be too late. With adequate policies, the preferred objectives of Chapter V, the preferred performance criteria presented in this chapter, coupled with appropriately derived measurements as discussed in the next chapter, perhaps action will not be too late.

B. OVERVIEW OF DATA PROCESSING AND USER PROBLEMS

The problems faced by DP executives are determining how much to invest in hardware, software, people, and measuring the performance of the DP organization. In other words, they are concerned with the question: are we providing the right products and services, in terms of computer capacity, performance, and reliability, and at the right price to the user?

Users face a different set of problems. Users require both performance and function (McFarlan et. al., 1973). Functional requirements are expressions describing what processes the application, equipment, and people do. The performance requirements are quantifyable expressions of how well the functions are performed. In addition, users are specialists in their own business profession. The user works with output units, such as invoices processed, checks processed, transactions processed, production scheduled, parts issued, etc. As a general rule, users do not care how the computer system works, as long as their requirements are met. That is, as long as DP provides the products and services they require at what they perceive to be fair, reasonable and understandable costs (Dolotta et. al., 1976).

Typically, the user does not understand his DP costs, and, therefore, cannot relate costs to requirements in order to make products or service trade-offs. As a result, they sometimes view the entire DP system as a failure. Hopefully, with the proposed objectives presented in Chapter V and the following performance criteria, users will have a better understanding of their costs and be able to make the necessary economical trade-offs.

C. THE STRATEGY

In general, chargeback algorithms measure how much of each resource (e.g., CPU time, memory time, channel time, pages printed, file space, control unit time, etc.) the application program used. The perspective is looking from the computer system in toward the application. By definition resource usage is time dependent. The resulting algorithm is complex (McKell et. al., 1979). It is expensive both in terms of overhead to run and cost of development and tuning maintenance. Additionally, the billings derived from the system are difficult for DP management to explain and users to understand. Thus, yearly budgeting, economic trade-offs (between service and products), and planning for the future is awkward for both the user and DP.

All chargeback performance criteria presented in Chapters III and IV (e.g. repeatable, accurate, equitable, comprehensive, etc.) are from this same technological (or inward looking) perspective. These criteria are certainly necessary, and form a firm foundation on which to judge the effectiveness of the chargeback model. They do not, however, by themselves (as history has proven) solve the users' predicament.

What is needed are performance criteria that are derived from a managerial (or outward looking) perspective (Rizzuto and Rizzuto, 1978; Cast et. al., 1983). That is, performance criteria that are independent of the computer environment.

Such criteria would place more emphasis and concern on the validity of charges to the user. As a direct consequence, the user would (Rizzuto and Rizzuto, 1978):

(1) have more confidence in his periodic charges;

(2) will be able to use the charges for planning;

(3) will be able to use the charges to make economic trade-offs (e.g., products for services);

(4) would have less tendency to question the resulting report of charges.

D. UNDERSTANDABLE PERFORMANCE CRITERIA

Instead of communicating the cost of hardware resources, software, and labor usage, as has been the case historically, the chargeback system (not the algorithm) should enable DP management and the user to communicate policy, service requirements, and DP executive directives. That is, DP managers should concern themselves with a managerial perspective that is solidly anchored in communications, as well as with the technological perspective of the chargeback model.

The following performance criteria can affect both the quality and the cost of DP products and services. Therefore, all the criteria need to be communicated before an effective and understandable DP service can be provided. The criteria DP should be concerned with are:

(1) THE IMPACT THE APPLICATION HAS ON THE SYSTEM--Applications impact essentially asks the question: what are effects of the users' application on the existing system and on the other users, in terms of capacity, performance, and availability? Applications that are inefficient users of system resources can be identified

and recommendations made for corrective software maintenance, in order to avoid having to bill the user with high costs (Rizzuto and Rizzuto, 1978).

(2) STABILITY OF THE APPLICATION--The stability of an application can impact on DP scheduling objectives and computer operations labor (Schaffer, 1981). Application stability asks the question: how often do changes applied to an application cause problems? If a user is constantly changing his application, or if it runs for a long time (wall clock time) without validation routines, then these facts should be communicated to the user, and a surcharge applied to the basic cost (derived from the chargeback algorithm) of running the application.

(3) THE APPLICATION'S OPERATIONAL IMPACT--Operational impact asks the question: what is the effect of this application on my staff? Is additional work or overhead expense required to support the application in the form of training requirements, specialized knowledge or labor. If so, then a surcharge should be tacked on to the basic cost presented by the chargeback algorithm.

Users, on the other hand, are concerned with:

(1) SERVICE LEVEL REQUIREMENTS--Service level requirements are set by the users' needs (Rizzuto and Rizzuto, 1978). The required response time, scheduling deadline or turnaround times are determined by the user. The resources and techniques for accomplishing user specified requirements are under DP management control. Therefore, DP management can determine whether the cost running the application should be higher or lower than the basic cost resulting from the chargeback model. (This is another call for the use of differential pricing). Computer performance evaluations such as load, contention, and service indicators can be collected periodically in order for DP management to assess whether the users' requirements are being met (Schaeffer, 1981).

(2) AVAILABILITY--Availability is another performance item that can impact on computer operations and on other users. For example, if a particular user application must be the first one back on line after a system crash or power outage or if the application requires lots of overhead at the expense of other applications, then a surcharge might be necessary. In addition, availability asks the question: when is the application scheduled to be run, and how reliable is it? (Schaeffer, 1981).

(3) INFORMATION STATUS--Information status asks the questions: can the information be obtained when needed? Is the needed information on-line, or off-line? Basically, information status is concerned with availability of needed information, the data structure, if it is accessable by many applications, and the peripheral device the data is stored on.

(4) DEDICATED RESOURCES--Dedicated resources is concerned with dedicated access channels, dedicated terminals, perhaps a dedicated small mini-computer, or dedicated operators.

E. THE DATA PROCESSING SERVICE AGREEMENT

Implementation of the above preferred performance criteria requires that a DP Service Agreement be established between the user and DP. The following four steps are recommended in establishing such an agreement:

(1) Identify the APPLICATION's FUNCTION. What exactly does this application do? For example, if the application processes transactions, then the number of transactions processed for the accounting period should show up on the users' billing along with the charges.

(2) Determine the SERVICE LEVEL REQUIREMENTS. That is, establish response time or turnaround time, the number of on-line terminals to be used, the time the application is required to run (e.g., Is it to be run during peak-periods?), if/when DEDICATED RESOURCES are required. Determine the AVAILABILITY and INFORMATION STATUS requirements.

(3) Determine SYSTEM and OPERATIONAL IMPACT and STABILITY of the application. In addition determine the EXPECTED VOLUME of traffic. This enables DP to plan resource usage and do job scheduling appropriately.

(4) DEVELOP A CHARGE. Once the expected volume service level requirements, availability, information status, and dedicated resources (if any) are agreed upon, the DP manager using the chargeback algorithm's charge as a base can develop a charge. Once an agreement with the user as to the appropriate charge has been reached, then the charge should be incorporated into the DP Service Agreement.

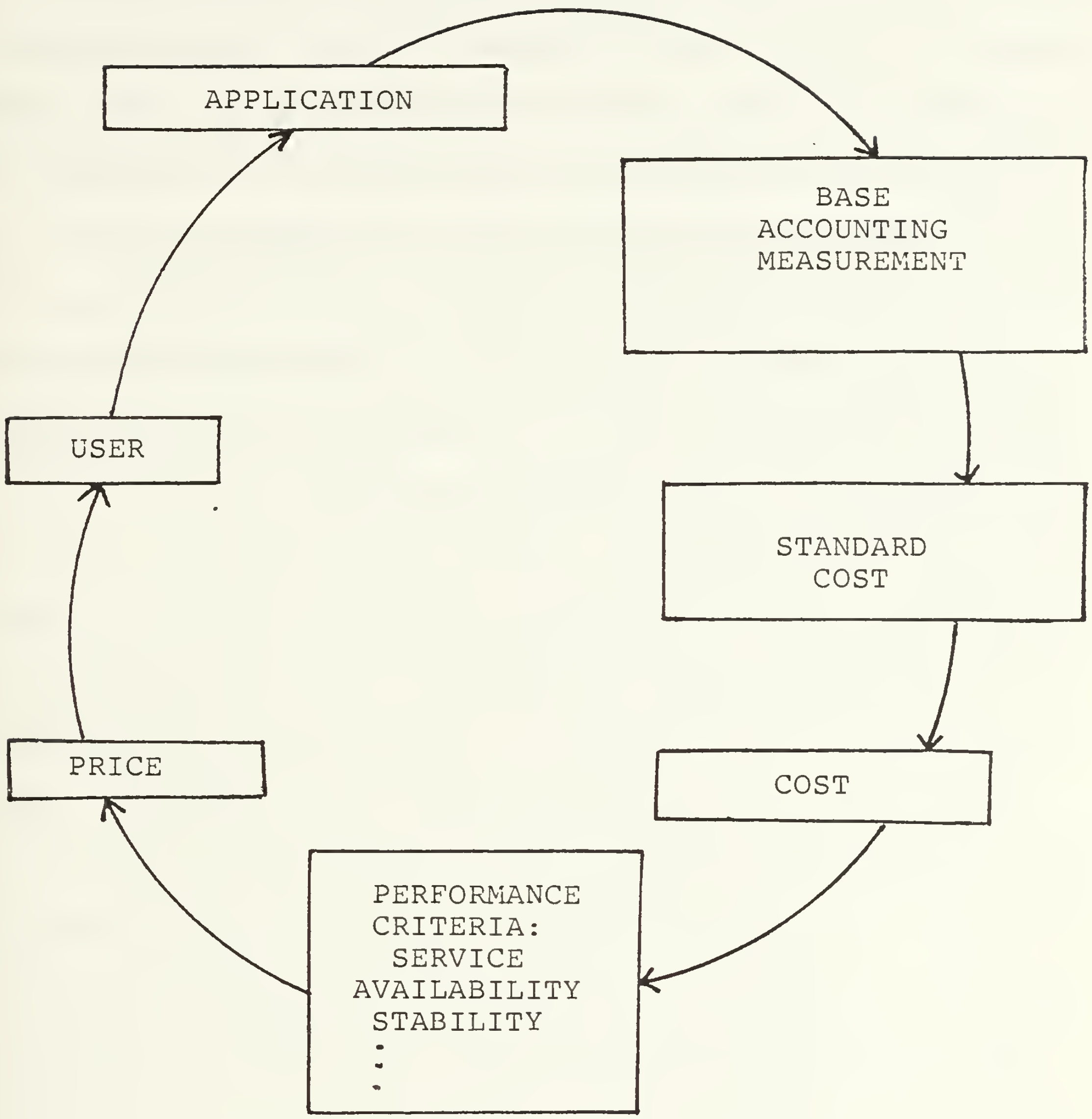

Figure 8 Developing a User Price

The question that users should ask themselves before signing the agreement is: what is the information derived from this application worth to my organization?

In summary, DP management and user management each have a vested responsibility in using the computer resources as an effective economic tool. User management is responsible for economically justifying the applications, and specifying the service requirements. DP management is responsible for understanding what the applications do, for ensuring the service requirements are met, and for ensuring the charges remain in the guidelines established by the DP Service Agreement. Figure 8 summaries the steps necessary in developing a price to charge the user.

VII. PERFORMANCE MEASUREMENT

A. INTRODUCTION

The purpose of this chapter is to explore both the concept and application of measurement as it relates to measurement in DP. To provide the reader with more of an understanding and hopefully a clearer insight into measurement theory, the exploration effort has been broken into a twofold task. First, an academic and somewhat philosophical approach will be undertaken to explore the underlying theories, models, and conceptual frames associated to measurement. Secondly, a more managerial and practical approach will be taken. A call will be made for measurement tools that bridge the gap between the users' view of performance against a standard and the evaluation of the causes of that performance. By approaching the measurement question in this manner, it is hoped the reader will gain more of an appreciation as to why the author has continually argued that a straight forward chargeback model (or inward looking perspective) is not necessarily the correct perspective when dealing with user performance standards and how to measure to them in a DP environment.

During this effort the author has found it necessary to make the assumption that measurement can be divided along what Flamholtz et. al. has termed the "three main traditions which have dominated the study of organizations: the sociological, the administrative, and the psychological perspectives" (1985, p. 37). Although both the pure sociological and psychological views have equal validity in organizational measurement and control, the administrative or managerial view provides more of a DP flavor not available in the other theoretical approaches. Accordingly, this analysis will be from the managerial perspective.

B. WHAT IS MEASUREMENT?

The results of the literature survey have uncovered three broad perspectives of measurement which appear to be hierarchical. First, discrete measures in themselves can be categorized along a continuum ranging from being descriptive to evaluative in nature (Van de Ven and Ferry, 1980). Descriptive measures are value-free in that they focus on factual characteristics and behaviors that actually exist or occur in the organization. Evaluative measures, however, are normative or value-laden, and are more affected by the individual's frame of reference (Van de Ven and Ferry, 1980).

Secondly, the constellation of measures can be considered a system of measurement by itself. Mock and Grove have defined a measurement system as "a specified set of procedures that assigns numbers to objects and events with the objective of providing valid, reliable, relevant, and economical information for decision makers" (1979, p. 220). Euske (1984) has identified four basic characteristics of a measurement system which are intrinsic to this formal definition. They are:

(1) VALIDITY--Validity refers to the degree to which the relations among the numbers are identical to the actual relations among the quantities being measured.

(2) RELIABILITY--Reliability (or accuracy) refers to the degree of variance that occurs in repeated measurements of the same attribute. For example, how much error is there in the measurement within the chargeback system of a users' application? If one application costs more to run than another, how reliable is that measure? The degree of accuracy will vary; the concern is not that errors exist in measurement but that there will be ways to identify and control the errors (Mock and Grove, 1979).

(3) SCALE TYPE--Scale type refers to the characteristics of the real number series that are used in a particular set of measurements. For example, the nominal scale is used as a means to classify items. The part number of an inventory item is an example of the use of the nominal scale. Another scale type is the ordinal scale. The ordinal scale is nothing more than an ordered nominal scale. The grades of beef, bond ratings, and different grades of diamonds are all examples of the use of the ordinal scale.

(4) MEANINGFULNESS--Meaningfulness refers to how understandable the measurement information is to the user. For example, if DP uses common terms to describe items on its billings to users, more users would probably understand the billings than if terms unique to computer science were used.

These characteristics exist in varying degrees across the spectrum of literature dealing with measurement and are essential in evaluating alternative systems. This is due primarily to the complex, multidimensional nature of measurement problems. An example provided by Mock and Grove (1979) is that of a valuation system. Such a system may be reliable if based on historical cost, but be less relevant than one based on appraised value.

Finally, the measurement system can be viewed as a component of a much larger organizational control system. The preponderance of managerial control literature supports this perspective. Flamholtz et. al. classifies measurement as one of the four core control mechanisms, along with planning, feedback and evaluation-reward, that "seek to influence the behavior of individuals within the organization" (1985, p. 38). The total control system is described by Flamholtz et. al. as a cybernetic process as follows:

> The cybernetic process begins with the planning activity which generates a list of work objectives and related standards for the operational subsystem. The outcomes of the operational subsystem are measured by various measurement systems which provide the information for comparison against the pre-established goals and standards. Observed deviations are fed back into the operational subsystem for corrective action and into the planning element for work goal or standard adjustment. Information from this planning element is further evaluated and used for reward administration. (1985, p. 39)

Such a view of cybernetic control is shared by most control authors although only Otley and Berry (1980) explicitly cite this term to describe the control cycle of planning, implementing, measuring, and correcting. In this case measurement is implied in the use of accounting procedures which, according to Otley and Berry, "serve as a control system by providing both a language and a set of procedures for establishing quantitative standards of performance and in measuring actual performance in comparison with such standards" (1980, p. 234).

Besides viewing measurement as a three-tier haierarchy, it also has a functional dimension. That is, what does measurement purport to do?

C. THE FUNCTIONAL DIMENSION OF MEASUREMENT

In most studies where this question has been addressed, the authors generally assumed that any measurement is a form of scientific measurement, and hence, as an ideal, measurement's function should seek to satisfy the principles of scientific measurement (Chase and Quiland (1973); Kircher (1959)). On the other hand, a number of authors (Mason and Swanson (1959); Euske (1984); Churchman (1959)) disagree with the assumed neutrality of the scientific measurement approach. These authors assert that the principles of scientific measurement largely ignore a factor that is crucial in measurement for management decision making, namely the individual. The scientific measurement perspective is interested in how well the measurement reflects the "true" nature of the object, whereas the managerial perspective asks the additional question: how well does the measurement relate to the users and their purposes? (Euske (1984); Grove, et. al. (1977); Miller and Masso (1983)).

The traditional view of measurement is that of an information communication vehicle. This functional view pertains "since it provides the information necessary for corrective action" (Flamholtz et. al., 1985, p. 39). As such, it is common to note that measurement is perceived as an ex post or feedback control device. Specifically, measurement involves the post hoc communication of information regarding deviations in performance outcomes from expectations establis-hed in the planning phase of the cybernetic control process (Flamholtz et. al., 1985).

Recent literature on measurement and organizational control, however, have proposed another dimension of measurement, that of behavior control. Flamholtz et. al. (1985) have identified four ways in which measurement influences work behavior in what is termed a psychotechnical system perspective of measurement:

(1) It serves as a criterion function by operationally defining the goals and standards of activities.

(2) It induces the manager to engage in systematic planning.

(3) It affects perception by producing an information set as inputs to the decision-making process.

(4) It causes attention focusing in those areas where results are measured or rewarded.

Another explanation of this effect on human behavior, and the decision-making process, is explained as a "functional fixation" aspect of human behavior. This is described in the following statement by Flamholtz et. al.:

> Individuals tend to focus more attention on areas where information is being requested. This measurement effort has been recognized as an explicit, intended mechanism of control. (1985, p. 40)

Functional fixation is related to an individual's frame of reference. In the next section the effect of the reference frame on the concept of measurement will be discussed in more detail.

In summary, however, measurement has both an informational and behavioral modification function. It acts as an ex ante, or feedforward control through its influence on work behavior. The ex post, or feedback view supports the traditional interpretation of measurement as an information system.

D. THE DEVELOPMENT AND APPLICATION OF MEASUREMENT STANDARDS

If there is any one mysterious side to the measurement process it is the standards utilized. These elements form the very foundation necessary for management control. Yet they seem to be formulated more by fiat than in scientific basis.

There is a dearth of literature on the subject of developing and applying DP standards. In the few articles that were uncovered, the common denominator is the satisfaction of some need. To the "traditionalists," this need is an information system supporting a management control system. The "behavioralists," on the other hand, view measurement as a control mechanism in itself. This divergence of conceptual views of measurement leads to what will be termed the "major schools of measurement." Each school identifies unique criteria it considers relevant to its own specific decision needs and then translates those needs into measurement systems and standards. The differences in these criteria become more pronounced as the data to be measured becomes less objective (e.g., effectiveness of service in DP).

An additional basis for developing measurement systems and standards is what can be categorized as management discretion. This relates primarily to the goals or objectives of the organization. The majority of control authors imply a goal-based measurement scheme to ensure goal accomplishment of the organization.

Ijiri (1975) stresses objectivity in measurement by specifically limiting the scope of measurement to the economic goals of the organization. As such, only those attributes which can be easily quantified and scaled (e. g., in chargeback...items like CPU time, cost, etc.) need by considered. This supports and affirms the inward looking perspective of chargeback discussed in Chapter VI, and explains why that perspective is so widely held. By restricting measurement in this fashion, the traditionalist framework has designed out conflicting forces to their measurement concept. Mock and Grove have noted that Ijiri's search for objectivity in measurement includes a scheme to "measure by consensus" in those cases where attributes are subjective and do not lend themselves to easy quantification:

> How do we know, a priori, whether one's perception of reality is closer to true reality then mine or your's? Material reality or objective reality without support by consensus is a dangerous concept, because it can often lead

> lead to theological exercises by those who claim to be able to see reality better than others. This is the essential reason why I seek the basis for objectivity in consensus. (1979, p. 229)

This explanation is an apparent attempt to insulate the traditionalist's model of measurement and provide it credibility in a subjective environment. Again, by (rationally) setting standards by consensus, the traditionalist is relieved of the requirement to justify his measurement scale and the underlying methodology. The model's validity and the uni-dimensional function of measurement is maintained.

In contrast, behavioralists view the measurement-goal relationship as both an information system and employee performance appraisal system. This is summarized by Flamholtz et. al. as follows:

> An initial set of goals and standards occurs, designed to channel individual or group effort toward organizational ends. Once set, these become performance standards which serve to function as ex ante and ex post control. They serve as ex post inputs to the evaluation-reward subsystem. Measurement directs attention toward measured dimensions of goals, and permits corrective and evaluative feedback. (1985, p. 34)

Thus, any management control measurement system, including a chargeback system, must be designed with primary attention given to the standards and goals of the organization, and to the process by which managers assimilate and act on measurement data (Churchman, 1959; Mason and Swanson, 1979; Miller and Masso, 1983). This is essentially the direction the author has tried to direct DP management with the outward looking perspective developed from the planning-operational framework and preferred objectives of Chapter V, and preferred performance criteria of Chapter VII. Unfortunately, at present there is little in the way of empirical studies that can be used to assist management in the design of such a measurement system.

In each school of thought, measurement serves to operationalize the goals within the organization. In addition, each school's approach suffers from a serious shortcoming. This centers on the fundamental problem of translating goals into workable standards and measures.

The complex nature of goals does not easily lend itself to accurate interpretation and translation. The time dimension quality of goals (i.e., short-term, long-term), goal ambiguity, and even conflicting goals within the same organization inhibit the transformation process. Some goals defy, outright, any attempt at quantitative translation. Consider, for example, the Navy Supply Systems Command's policy of "Service to the Fleet" or the NARDAC's policy of "Quality Service."

In view of such a critical link-pin problem it was surprising to note a complete absence of literature on the subject. Most goal-oriented authors concede only a problem in goal-subgoal coupling. It is in this area that they have concentrated on devising corrective systems. Management By Objectives (MBO) is one such device. MBO is a "top-down" method for establishing total system goals and communicating them downward in such a way that each level of the organization can translate them into specific operational objectives (Fink et. al., 1983). However, it appears more oriented toward generating goal congruence among the organizational members than in providing a vehicle to translate goals into operational standards. Therefore, this author would argue that a system more along the lines of IBM's Business System Planning (BSP) is more apropos in a DP chargeback environment than either MBO or Zero Based Budgeting (ZBB).

Another approach is a "means-end" chain of goal development. The empahsis in this type of an approach is to ensure goal-subgoal coupling and integration within the organization (Fink et. al., 1983). If this is achieved, the implication is that effective measures can be obtained as a direct result of the process. The validity of this argument is questionable. First, without designing in specific consideration of standards development at each coupling point there can be no guarantee that goal-subgoal coupling will, in fact, be accomplished. Secondly, these approaches only consider the quality control of goal development. The need exists to verify standards concurrently with goal validation otherwise both the feedback and feedforward value of these tools will be suspect. This is why the care in developing the DP Service Agreement was stessed so emphatically in Chapter VI.

The application of measurements is also complex. Simon (1981) notes an interesting dichotomy in that something cannot be accurately measured without first obtaining a complete understanding of its nature. To impose a measurement scheme is to imply an expected behavior characteristic or outcome.

In addition, the very act of measuring may change the physical characteristics and attributes of the item being measured. This anomaly, discovered by Heisenberg in measuring scientific phenomena, now bears his name. Similar anomalies were discovered as a result of the Hawthorne Studies, although directed at human behavior rather than scientific phenomena (Fink et. al., 1983). In this case, the awareness of task measurement was responsible in causing factory workers to display greater efficiency on the assembly line. Such a behavioral impact supports the previously mentioned ex ante control view of measurement.

Finally, the application of standards and measures involves the use of surrogates to describe principals (Euske, 1984). These artificialities are, in their most basic sense, symbols which like the data they represent, are abstract concepts in themselves. The tendency is then for individuals to associate unique meaning to the surrogate that goes beyond describing the basic characteristics of the principal alone (Euske, 1984). As such, the symbol takes on a special meaning apart from the principal it purports to measure. Therein lies the root of the entire problem of measuring to performance standards. By applying some sort of measurement scheme to a phenomenon, we attempt to import objectivity and, therefore, legitimize to the outside world the frame of the control system we are using and create reality where there is, in actuality, no reality.

E. MEASUREMENT TOOLS

It has been said, "if you can't measure it, you can't manage it." A corollary is that it is meaningless to have a management standard if there is no way of determing where you are relative to that standard. In the same vein, it is also meaningless to measure where you are relative to a standard that is itself irrelevant. For example, to a user who has not been receiving reports on time, the throughput and turnaround time from 1:30 A.M. to 2:30 A.M. on the computer would not be exactly relevant nor meaningful. The user only understands one thing, and that is --my report schedule has been met only 50% of the time.

As the preceding discussion on the theory of measurement indicated, there are many factors that must be taken into consideration when setting standards and developing measures to those standards. In Chapter VI various preferred performance criteria (or standards) were recommended. The emphasis was on communications between DP and user management. To that end, it was argued that a DP Service Agreement be established between the DP organization and the user, and that the agreement call out the performance criteria and the evaluation methods to be used. Unfortunately, as previously stated, there is little in the way of empirical studies that can be used to assist DP management in the design of such a measurement system. Essentially, what is needed are measurement tools that bridge the gap between the users' view of performance against a standard and the evaluation of the causes of that performance.

First there exists a need for tools which measure actual DP performance against user and DP agreed upon performance standards. Computerized tools of this type, however, are almost nonexistent. For example, measuring the percent of time computer services were available to users on schedule (a preferred criterium) must currently be done by manual means. Probably the most relevant manual process is to have the terminal user record responses in a log book according to a predetermined sampling plan (Schaeffer, 1981).

Secondly, there exists a need for tools that relate a high level standard to lower level measures. That is, tools that relate why reports are late to DASD I/O contention, CPU load, computer unscheduled down time, etc. For example, the reason the users' reports were late in the preceding example might have been because of DASD I/O contention, channel capacity, CPU load, or simply because the output room personnel were behind in separating, decolleting, or delivery. Facts such as these need to be communicated to both DP management and the user. Therefore, reports are needed to summarize this kind of information so that the DP manager has an understanding of his operation's performance as perceived by the user before the user approaches him for an explanation. Again, unfortunately, such tools are not standard, and must be developed locally (Schaeffer, 1981).

Thirdly, there exists a need for an organized approach to analyzing problems relative to the criteria (standards) agreed to by DP management and users. That is, given a set of committed performance criteria, there must be regular (e.g., at least once a week) performance measurements of how well the DP organization is performing to the user-DP-agreed upon criteria. The results of the measurements must be easily understood by the users and defendable by the DP management. This implies that criteria cannot be set "willy-nilly," but only criteria that can and will be measured are established and communicated.

F. CHAPTER SUMMARY AND CONCLUSIONS

Measurement in the context of managerial control is an abstract concept that is glossed over in most management literature. Most DP managers and academicians find it easier to talk in terms of computer performance evaluations, input/output, and so on. By diverting the discussion away from the subjective and remaining within the confines of the familiar, they can effectively side-step the problem of

"How are effective managerial control standards and measures to them established in a DP-user environment?" Measurement's validity and relevance are determined within consensusally defined frames of objectivity. These frames, in turn, can be identified to two major schools that view measurement as either purely informational/feedback (the traditionalist) or as behavioral control/feedforward (behavioralist).

Each frame is carefully constructed to ensure internal validity of the basic view. When analyzed from an unbiased perspective outside of the established framework, each falls short of providing a complete, integrative model of measurement. A need exists to develop such a model. A need noted by Flamholtz et. al. from the aspect of managerial and organization control:

> In sum, the lack of theoretical integration and the relative inattention to measurement have limited our understanding of the nature of the control process in complex organizations. (1985, p. 37)

In short, measurement is not as objective as most people believe, does not exist away from the application it purports to measure; and cannot be transported from application to application.

VIII. NAVAL DATA AUTOMATION COMMAND/NAVY REGIONAL DATA AUTOMATION CENTER MANAGEMENT GUIDELINES

A. INTRODUCTION

The operation of the NARDACs takes place in a much wider context than explicitly discussed thus far. This context serves as both a constraint and an opportunity. The context is largely organizational and involves:

(1) The relative freedom allowed an individual NARDAC.

(2) The user command's attitude and experience with computers.

These factors must be recognized and taken into consideration in any chargeback design strategy. For example, the author has stressed the importance of designing a chargeback system that is:

(1) based on differential pricing;

(2) has a managerial perspective that espouses the objectives of financial control and DP-user goal synchronization, and incorporates the performance criteria of Chapter VI;

(3) incorporates both planning and operational control into a synchronized management control loop.

The above context, however, acts as a constraint on how flexible an individual NARDAC can be. Lines of authority, predefined responsibilities, reporting requirements, and so on limit the discretionary power of the NARDACs. One of the frustrations many readers of academic papers such as this experience is that these constraints are generally brushed over and the recommended strategies presume that Navy DP managers are masters of their fate. Nevertheless, the chargeback objectives and criteria discussed in Chapters V and VI can be incorporated into the Navy's DP plicy and procedures over a reasonable time span by the DP executives at the NAVDAC level. In this chapter, the main aim is to sketch out a "climate" that will provide a suitable environment for the NAVDAC/NARDAC complex to operate once the above policy changes have been incorporated.

B. THE IDEAL CLIMATE FOR THE NAVY REGIONAL DATA AUTOMATION CENTER CHARGEBACK SYSTEM

As stated before, senior DP managers at the NAVDAC level do have the power to alter the Navy's DP chargeback infrastructure and procedures. Therefore, the organizational climate best suited to chargeback can be appropriately outlined.

In the ideal climate, chargeback is not regarded primarily as a mechanism for cost allocation. Viewing chargeback from a purely cost allocation perspective fails to acknowledge that charges have a direct influence on user attitude and behavior. In addition, it fails to recognize that a main motivation underlying charging is to control computer activities.

The NARDAC chargeback system will only be fully effective if these underlying management control objectives are explicitly considered in the design of the charging system, so as to ensure that the desired influence on the user does in fact occur. Bernard et. al. emphasizes the need to recognize these underlying objectives by advancing the following argument:

> The key objective in designing a price structure should be to produce charges that will have the desired influence on the users; though equity will obviously be a major consideration in pricing, it should not be the central one. Computer charging schemes are often made very complex in order to achieve great accuracy in measuring users' resource consumption. Such complexity is expensive and often leads to charges that are incomprehensible to the user; the accuracy obtained is of value only to the extent that it is likely to materially affect users' decisions, and to the extent that resulting improvement in effectiveness and efficiency justifies the cost involved. (1977, p. 19)

In the ideal climate the computer resources are both centralized and decentralized. It has a lower tier of well-controlled, well-structured procedures. These include the chargeback model so that users recognize that there is a direct cost to them for computer resource usage. In addition, it has sufficient slack in terms of dollars and personnel, so that it can maintain a research development focus. For example, if the Commanding Officer of a NARDAC feels that more advanced data management techniques, or Decision Support Systems (DSSs) offer potential benefits to his users, he can assign people and resources to explore them. The contacts with user commands must be flexible enough to allow communications on an ongoing basis with them about such potential opportunities. In addition, user commands must have sufficient flexibility, confidence, and expertise to provide contact impetus for new applications. This implies that user commands are planning their DP future as well.

To be effective at the above, NARDACs must include several people who have either come out of a typical users' command or have substantial background in the typical user command's administrative, reporting requirements, and needs. In other words, the ideal climate will involve extensive cross-fertilization between the "computer experts" and user commands.

In the ideal climate, computer training is not something tacked onto the NARDAC functions, with annual eight hour seminars on time sharing, teleprocessing, and the wonders of database management. Formal mechanisms must be established at the NAVDAC level for building this "mutual understanding" within the Navy's NARDAC-user community. This lack of mutual understanding has been picked out time-and-time again as one of the main impediments to progress in DP. A joint DP-user educational design effort beginning at the NAVDAC level is the best mechanism for such education.

The ideal climate is reasonably attainable by balancing the twin demands of computer resource efficiency and effectiveness with a major emphasis on service to the user as prescribed in Chapters V and VI. An important aspect of this ideal climate is that it requires a very definite type of computer professional and also a special kind of client-user.

To support and underline this key point, the author offers this argument first advanced by Gibson and Nolan (1974) in their original four stages and later reinforced by Cash, et. al.:

> After field studies over a seven-year period on 28 organizations, we have concluded that the managerial situation can best be framed as one of managing technological diffusion. This approach usefully emphasizes the enduring tension that exists between the efficiency and effectiveness in the use of IS. At one time, it is necessary to relax and let the organization search for effectiveness while at another it is necessary to test the efficiency to maintain control. (1983, p. 29)
>
> This calls for subtlety and flexibility from IS management and general management that too often they do not possess or see the need for. A monolistic IS management approach however, will not do the job. (1983, p. 31)

C. CHAPTER SUMMARY AND CONCLUSIONS

The reader will recall that the NARDACs were conceived, designed, and staffed in the late 1970's and early 1980's. They were implemented into an area where chaos existed, therefore, simplistic and mechanistic approaches to management control, planning, and so forth were a great improvement over what was there before. Unfortunately, the initial surge of value from their introduction is slowly eroding away. Dealing with this erosion problem will require the introduction of more complexity and flexibility in the approaches used to adapt them to the changing DP environment. This chapter proposed an "ideal climate" that will provide for the required complexity and flexibility. This ideal climate is reasonably attainable if the twin demands of computer efficiency and effectiveness are balanced with a major emphasis on service to the user. The elements of the ideal climate are:

(1) centralized and decentralized computer resources;

(2) a joint DP-user educational design effort that builds mutual understanding within the Navy's NARDAC-user community.

One of the major weaknesses of the NARDAC chargeback system is that its billings are not firmly rooted in user management's reality. To gain a level of user support that will assure future success will require anchoring the chargeback system in the users' perspective. The preferred objectives of Chapter V, the preferred criteria and the DP Service Agreement of Chapter VI, coupled with the DP climate described in this chapter serves to assist DP management in establishing a foundation on which to build this required and necessary joint DP-user perspective.

Granted, the diffusion of DP technology within the Navy must be controlled and managed. However, if poorly managed it will not evolve into the invisioned well-functioning DP support system; but will more than likely degrade into a collection of disjointed and confused islands of technology similar to what existed in the mid 1970's.

The Navy's NARDACs offer DP opportunities that are immense. Immense in that computer technology within the Navy can be standardized, can keep up with industrial improvements in hardware and software, and above all, can be imbedded in routinized labor intensive administrative, reporting, and decision making activities where it can provide large economic pay-offs to users. To enjoy such immensities, however, presumes that the NAVDAC/NARDAC complex will continue to evolve in its thinking process, and begins to more agressively market and manage its resources and services. If this evolutionary thinking and marking process stagnates, Navy may end up with another technical success but an administrative failure.

IX. SUMMARY AND CONCLUSIONS

The computer exists solely to help users execute their responsibilities better through cheaper processing of data, more efficient organization of information systems, and as a dispersant of information that is too expensive to obtain by any other means. The resource has no justification for existence except to provide service to users, and these services must allow the user to do his job more efficiently. In short, as Dearden and Nolan so succinctly state "...the computer has a purely economic purpose." (1973, p. 69)

If the computer is an organizational resource and should be made to serve an economic purpose, then the question that has to be asked and answered by DP management is: how should this resource be managed? The DP chargeback system is one of the most important tools for facilitating management and control of computer resources. If properly implemented and operated, it can improve the planned procurement, allocation, and cost recovery of computer resources. Additionally, a properly managed chargeback system can be made to act as the formal economic communication system between DP management and users. When lacking or improperly managed, however, opposite results can occur. For example, a DP manager who ignores the users' understanding of computers and charges in terms heavily couched in "computereze" is proposing a system that is doomed from the start to mediocrity or worse, failure. On the other hand, a DP manager who throws up his arms and argues that a chargeback system cannot be designed that will work is ignoring the tremendous economic efficiencies that it can offer.

The attainment of these economic efficiencies requires emphasis to be shifted from a purely technological (or inward looking) perspective to a managerial (or outward looking) perspective. Intrinsic to this effort is a management control system that incorporates the DP executives', DP manager's, and users' viewpoint of computer resource usage and charges.

The chargeback system is meant to make users more cost conscious and to force them to evaluate value received against the cost of services provided. Simply stated, a chargeback system is nothing more than an involved measurement system with a feedforward mechanism (ex ante) for development of DP policy and procedures, and a feedback mechanism (ex post) that continuously monitors DP management's progress toward attainment of the overall chargeback objectives. Acting in this manner, it should provide information that will allow DP executives to guide the behavior of users.

The underlying premise of this thesis is that in addition to equating DP management control effectiveness to measuring the life cycle cost of the computer, these measures must also include how effective the computer resources are being allocated. Thus, to be effective, the system must be designed with primary emphasis given to the policies and objectives of the organization and to the process by which users assimilate and act on charges. To be effective at this task, the chargeback system must allow for differential pricing. Therefore, it is rational, if not vital, to charge the user in terms that are relevant to him. The charges should be in terms that will allow users to have a better understanding of what they are paying for. The chargeback system should also allow users to plan and predict their future expenditures for DP. The user must be able to understand all facets of the chargeback system; the meaning of the resource unit being measured, the method designed to measure it, how the service rates are determined, and the amount of control he has over the service provided and resulting charges. This requires the chargeback system to provide:

(1) financial control;

(2) DP-user goal synchronization;

(3) and a means for formal communications between users and DP.

The users must be provided with enough information to be able to complain, demand explanations, and request adjustments intelligently. If they cannot do these things, they probably do not understand the chargeback system. Additionally, the chargeback system should provide the DP manager with an indication of the future volume of usage so that procurement of computer resources can be anticipated and the future for DP planned.

Chapter I began by discussing the overall objective and purpose of this thesis. In addition, the reader was presented with a wide perspective. In developing the initial perspective, the following topices were discussed (1) NARDAC's mission; (2) a definition of a management control system; (3) the role that a management control system plays in an organization; (4) a brief overview of a "generic" chargeback system; and (5) some problems facing design of a chargeback management control system.

Chapter II provided a more in-depth look at a typical NARDAC by examining: (1) its mission and function; (2) its organizational structure; and (3) its client-users.

Chapter III provided the reader with a basic academic overview of a chargeback system. The following topics were discussed in-depth: (1) the establishment of management goals; (2) the objectives of a chargeback system; (3) the typical chargeback performance standards (or criteria).

Chapter IV discussed the NARDAC chargeback system in-depth. In particular, the NARDAC's management policy and objectives for the system, billing algorithm and rate determination, performance criteria, and performance evaluation methods were explained. As the discussion moved along, some of the weaknesses of the system were also pointed out.

In Chapter V, key objectives of a chargeback were identified and discussed. The preferred objectives were: financial control, and DP-user goal synchronization. An explicit recommendation was made that a need existed to synthesize from these a strategy for DP control that exploits the relative strengths of each. The stress throughout the chapter was on the critical value of DP management and user interaction and communication. Central to the attainment of the objectives was the development of an integrated planning and operational loop. In fact, the definition of a chargeback system as presented within this thesis is, in many respects, nothing more than an effort at building a framework that can accommodate particular aspects of DP management-user interaction on an opportunistic basis.

Chapter VI discussed preferred (or key) performance criteria. The chapter stressed the point that for a chargeback system to be effective, it has to support DP-user communication as defined in Chapter V. Effective communications requires the formulation of a DP Service Agreement with the user for every one of his applications. The DP Service Agreement must address all seven of the preferred criteria, and be formulated in a specific stepwise fashion.

Chapter VII explored both the concept and application of measurement. An attempt was made to answer such questions as: What is measurement?; What are the functions of measurement?; How are measurement standards developed and applied?;

and, What are the measurement tools currently needed to measure the preferred criteria as set forth within Chapter VI?.

Chapter VIII prescribed an "ideal climate" for the effective operation of the NARDAC chargeback system. While the discussion was slanted toward the Navy's DP environment, the arguments can be applied equally well to a DP operation within a commercial enterprise. First, a two-tiered structure for a NARDAC was recommended. The lower level would consist of well-structured, well-controlled procedures that include the chargeback system. The second level would have sufficient slack in terms of dollars and personnel so that a NARDAC could maintain a research and development focus. Secondly, a joint user-DP educational design effort starting at the NAVDAC level was called for.

A chargeback system may be likened to a lens through which a user views the DP organization. As with any lens, chargeback can magnify, reduce, contort, or distort the users' images of reality. Thus, the chargeback design problem becomes one of how best to fit the user with the chargeback lens that best assists him in the achievement of his organizational objectives. The strategy developed and discussed in the above chapters lays the groundwork for assisting Navy DP managers in fitting that lens to the user.

The author has conscientiously tried to present a specific and practical approach to chargeback systems design that can actually be used by Navy's NAVDAC/NARDAC complex and the private sector as well. The proposed system can be implemented now and exploits the joint but different capabilities and perspectives of DP executives, DP managers, and users. The proposed system can be absorbed and acted upon by all participants very quickly. Moreover, the proposed system makes success of Navy's NARDAC chargeback system a little more likely. The adjustments that each participant needs to make to accomplish this are not great, they are mainly attitudinal, and require little new knowledge. But, and this is an important point, the opportunities for action are substantial, and the organizational rewards exceptionally high.

The author does not in any way defend the results of this thesis as more than a reasonably robust and general paradigm that hopefully clarifies and provides the reader with some insights into key issues that are relevant to designing an effective chargeback system as a management control tool. In fact, intrinsic to DP management is the notion that a chargeback system is just one tool in a large tool box of many management tools needed to manage and control DP.

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